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LOWER CRETACEOUS DEPOSITS IN CALIFORNIA AND OREGON

BY
F. M. ANDERSON

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INTRODUCTION AND ACKNOWLEDGMENTS

Geological and paleontological work on the Cretaceous deposits in California and Oregon was begun as early as 1854, but in great measure the foundations upon which all subsequent work has been based were laid by J. D. Whitney, W. H. Brewer, and W. M. Gabb in the period from 1860 to 1884. This work was followed by that of G. F. Becker and C. A. White, and from 1891 to 1905 by the more important work of J. S. Diller and T. W. Stanton, from whose results all later work has proceeded. The knowledge of the stratigraphic succession and the faunas of the Cretaceous in California and Oregon developed by these later workers was a great advance from the generalized results of the earlier explorers. But it soon became evident, however, that other demands upon their time had left this work unfinished, far from the stage to which their interest and energy would have led them to attain. As concerns the early Cretaceous deposits, their stratigraphic limitations, relationships, and distribution, further advance was hardly possible prior to 1907 and the three succeeding years. During these years some notable advance in Cretaceous paleontology was made by Pavlow (1907), Diller (1908), Smith (1909, p. 347–349), Knowlton (1910), and others. The work of these men led the way to a solution of a primary problem—namely, a proper discrimination of the Lower Cretaceous from the late Jurassic sequence in these western States. A brief review of this subject was given by the writer (1933, p. 1237–1265), with a summary account of the more recent work done on the west border of the Sacramento Valley in California in tracing the boundary between these great sedimentary series.

It was pointed out that, in many areas of contact between the Knoxville (Upper Jurassic) and the Shasta (Lower Cretaceous) series, evidences of unconformity are abundant, clearly showing that an interval of disturbance and of erosion had intervened, which seems to have extended along the Pacific Coast from California to Alaska, and far beyond.

Prior to the last decade, a knowledge of the stratigraphic subdivisions in the Shasta series in California and Oregon and of their respective faunas was quite imperfect, and conceptions of these matters were much confused owing to the lack of criteria by which satisfactory distinctions could be made. During these years a number of notable contributions were made to the paleontology and faunal succession of the Lower Cretaceous in other parts of the world by Spath (1924), Whitehouse (1926), Steinmann (1929), Burckhardt (1930), and others. These works have made it pos-

sible to attain a more satisfactory interpretation of the faunas found in the Lower Cretaceous deposits of the West Coast. These works have also led to a desire to obtain more definite information as to the stratigraphical and faunal successions in the richly fossiliferous strata of the Knoxville and Shasta series in California and Oregon, and a persistent effort has been made in recent years to do this. As a result large collections of invertebrate fossils have been gathered from the lower units of the Shasta series and from the upper units of the Knoxville in California and Oregon, and it is now possible to fix more definitely the line of demarcation between them, even in areas in which stratigraphical unconformity is not evident. However, it is not believed that either class of evidence is complete, or that mapping will always be easy.

Two major stratigraphical groups have been recognized in the Shasta series in California, both of which were foreshadowed in the work of Diller and Stanton, although these writers did not go so far as to distinguish them clearly. These are the Paskenta group below and the Horsetown group above, bearing evidence of a disconformity between them, as will be shown in the following pages.

In its general faunal aspects the Shasta series presents two distinct or not closely related faunal assemblages corresponding to the major stratigraphic groups, both of which are distinct from that of the Knoxville series. The study of these assemblages reveals cogent evidence as to important diastrophic changes of wide geographical extent supporting the deductions derived from the stratigraphical relationships in the field.

In the Paskenta group there are many forms of Mollusca, including Aucellas and cephalopods, the nearest analogues of which are found in contemporary deposits in Russia, as noted by Pavlow and earlier writers. In fact suggestions have been made by Stanton and others as to routes of migration, or of exchange, between Russia and western America.

The boreal character of *Aucella* has suggested routes of exchange by way of the Arctic seas, notwithstanding the fact that species of this genus have been found in lower latitudes (Mexico and India).

Students of paleontology, for whom this memoir is chiefly intended, should they desire a knowledge of the West Coast faunas before knowing their stratigraphical order, sources, and correlations, will find it in the second part of this volume.

But doubtless, to many students of geology it would seem more logical to consider first the deposits themselves, their stratigraphic order, the physiographic conditions of their period, and their other aspects; and these involve the nature of the sediments, their distribution, volume, attitude, sources, transportation, and the many details of their deposition. However, these aspects of the study should also be of interest to students of paleontology.

It is a pleasant duty to record here the interest and cooperative spirit shown toward the enterprise of this memoir by many friends and students of geology during the several years of its progress. It is of course impossible in the limited space available to give due recognition to all who have directly and indirectly aided in attaining the results here presented and who should share in whatever credit may be due. First among those to whom the writer feels a debt of gratitude for his stimulating interest, encouragement, and helpful advice, is the late James Perrin Smith, long-time Professor of Paleontology at Stanford University. His interest in such work and his example in this field of research have been an inestimable source of inspiration to many students and co-workers in this field, including the writer, and this debt will not be forgotten. For more material aid in this work, in the field, and in the laboratory, without which it could hardly have been undertaken, unreserved recognition should be accorded the California Academy of Sciences, its official staff, and its supporters, and especially the enthusiastic cooperation of G. Dallas Hanna, Curator of Paleontology, and other members of his Department. With the aid of Dr. Hanna and with the cooperation of the Director of the Academy, much of the necessary financial support of field exploration and facilities for the preservation and study of the materials collected have been provided, and of equal importance was the acquisition of the essential literature not already at hand.

Great interest and much material aid have also been given by the State Division of Mines under the direction of the State Mineralogist, Walter W. Bradley. To this institution, to its Chief Geologist, Olaf P. Jenkins, and to other members of the staff, is due sincere appreciation for aid in field traverses, structural study, and the recognition of the formations concerned. Acknowledgment is also accorded Norman E. A. Hinds, of the University of California, and R. Dana Russell, for valuable field assistance and for the results of their work in the Cottonwood district, and at Redding Creek, Trinity County; also for their structural studies, traverses, and fossil collections in these areas. To the Texas Company, and its Chief Geologist, Ralph D. Reed, and to his associates, is due much appreciation for practical and technical aid. The traverses and profiles along McCarthy and Redbank creeks, western Tehama County, are the independent work of A. I. Gregersen and R. W. Burger, of the Texas Company.

Among those who have participated in these field explorations should be mentioned with appreciation Thomas Stipp, Cordell Durrell, Parker D. Trask, and Hubert O. Jenkins. To the Chief Geologist of the Associated Oil Company, Mr. J. A. Taff, and to his associates, C. M. Cross and C. C. Church, thanks are due for traverses, field notes, and fossil collections made along Dry Creek, Tehama County, and in the vicinity of Mount Diablo, and in the Diablo Range.

Mention should also be made of the geological results of the Standard Oil Company of California, for which thanks are due G. Clark Gester, J. M. Kirby, and Theodore H. Crook for notes, sketches, and contributions of fossils obtained from various districts on the west border of the Sacramento Valley, and from other places.

The aid given this work by members of the geological and paleontological staffs at the University of California cannot be passed over without appreciation. The same kind of recognition and thanks is extended to the Department of Paleontology at Stanford University, and to the State Agricultural College of Oregon. Field notes and fossil collections from these institutions have been placed at the service of the writer in a spirit of cooperation that has been most gratifying. The section along the North fork of Cottonwood Creek, Shasta County, contained in this memoir, is the work of E. L. Packard and his students of the Oregon State College, checked by traverses by the writer and his associates. This work is of special value for its bearing upon the stratigraphic and faunal successions of the Horsetown group in its type area. Of equal importance is the work of Dr. Packard and his student associates in the southern counties of Oregon. Their work and fossil collections are the basis of much of our present information upon the stratigraphy and paleontology of the Riddle and Dillard areas in Douglas County.

Financial assistance for part of this study was received from the Penrose Bequest of The Geological Society of America.

PART I. STRUCTURE AND STRATIGRAPHY

CRETACEOUS EMBAYMENTS

GENERAL STATEMENT

It is assumed that the readers of this memoir know somewhat of the late Mesozoic marine troughs, basins, and embayments that existed along the Pacific border of the continent, including those of California and Oregon. Nevertheless, in view of some misconceptions that still exist as to these conditions it may be well to review briefly some of the more pertinent facts concerning them. It should be conceded that these Cretaceous troughs were for the most part inherited from earlier Mesozoic time, although the exact dates of their inception and development may not be fully known. From the viewpoint of broader Mesozoic history one may assume that many, if not all of them, had their beginning in the later part of the era, probably in late Jurassic time, when extensive readjustments took place in other continental areas of the world. In California and Oregon the Nevadian revolution occurred near the close of the Kimmeridgian, or about the beginning of Portlandian time, and this disturbance which profoundly affected the Pacific Coast was doubtless a major factor in the origin of these troughs. In California and Oregon the latest Jurassic deposits—the Knoxville series—occupy parts of these already developed embayments. Their deposition followed the Nevadian revolution. At the close of Knoxville time further changes took place in the physiographic conditions within and about these troughs without destroying their continuity, and perhaps without wholly changing their marine life, although profoundly affecting it. At the same time many new and unfamiliar elements were introduced into its molluscan assemblages. From its beginning, and throughout Cretaceous time, these Mesozoic troughs were still occupied by the sea, and in them were laid down the early Cretaceous deposits. The results of the post-Knoxville disturbances are known chiefly from a study of the earliest Cretaceous deposits, their distribution, volume, character, and attitude, and from the character of their faunas, their relationships in the various troughs, and in contemporary deposits in other parts of the world. Not all the aspects of such a study can be undertaken here.

Present information supports the assumption that the several areas of these deposits strewn along the Pacific border represent for the most part so many separate marine embayments that existed here during the period and that their present distribution is not the result of post-Cretaceous

folding, tectonic displacements, and subsequent denudation of a one-time more continuous sheet of sediment. One may believe that the sediments now found in these several areas were derived from neighboring land areas, in part near at hand, and in part distant from their places of deposit, and that, in some cases, they may still be traced to their sources. However, interpretations as to environment, source of sediment, lines of transportation, and entrance into their places of deposit, should be guided by physiographic conditions actually observable.

OREGON EMBAYMENTS

In southwestern Oregon the early Cretaceous seas entered the coastal embayments now known in Coos and Curry counties (Elk River and lower Rogue River) and also extended into trough-like depressions now occupied by the Umpqua River and its tributaries in Douglas County (areas of Dillard, Myrtle Creek, and Riddle). From the known distribution of the Cretaceous deposits in Curry and Josephine counties one may infer that a marine channel had extended inland south of the Rogue River Mountain as far east as the valley of the Illinois River, and at a later epoch into the principal valley of the Rogue River, which connected at the south with the valley of the Shasta River.

To the north of the Umpqua Valley (Myrtle Creek and Dillard areas), Cretaceous deposits are probably covered by those of the Eocene and later Tertiary, as Diller (1898) has shown in his geologic map. There is no known evidence that the basins of southwestern Oregon were connected with that of the Great Valley of California, or with any other basin to the east. The trough flanking the Blue Mountains on the south seems to have had an independent outlet to the northwest.

SOUTHERN COASTAL EMBAYMENTS

In California, south of the Great Valley, and extending eastward into intermontane valleys in the Coast Ranges, are other lesser embayments occupied by early, or in part by later, Cretaceous deposits. The extent of these troughs and their special structural and historical features are still imperfectly known. In the past study of these areas, little attempt has been made to distinguish the late Jurassic (Knoxville) beds from those of early Cretaceous, and, until this is done, little can be said about their early history or their later Cretaceous deposits.

The Santa Lucia trough, as it may be called, lies along the west border of the Salinas River Valley. It seems to have had its inception in middle or later Jurassic time and to have opened toward the northwest between the present Santa Lucia and Gavilan ranges. It probably had connection with the open sea near Monterey Bay and possibly with the south end of the Great Valley of central California. Toward the southeast its deposits extend across the present axis of the mountains north of San

Luis Obispo, and from there they continue eastward along the northern flanks of the San Raphael Mountains to the drainage area of the Sespe River and neighboring streams.

The eastward terminus of this trough has not yet been ascertained. Its deposits include both late Jurassic (Knoxville) and early Cretaceous sediments, and perhaps later Cretaceous, but up to the present these have not been segregated or completely mapped. They are partially shown on the geological map of the San Luis quadrangle (Fairbanks, 1904).

A more southerly trough extended in a somewhat parallel direction across southern Santa Barbara County, where both Knoxville and Shasta deposits are exposed along the northern flanks of the Santa Ynez range and in some of its axial areas farther west.

The axis of this trough may have extended eastward through the Simi-Chatsworth area and even to the south flank of the Santa Ana Mountains. Whether it extended farther and connected with the Cretaceous areas in Lower California is not known, although scattered areas of Cretaceous, and outliers of older rocks off-shore, suggest this.

GREAT VALLEY EMBAYMENTS

The larger California trough of the Great Valley existed as such throughout Cretaceous time as an inheritance from the late Jurassic epoch represented by the upper Knoxville. Whatever the incidents of transition may have been, it appears that in the early part of Cretaceous time the sea entered the embayment near the present position of San Francisco Bay, as well as at other points to the north and south of it.

More than one inlet existed leading into this now almost land-locked basin, as indicated by the deposits of early and of later Cretaceous age. The longitudinal extent of this trough exceeded 400 miles, but in width it was in part greatly restricted, more particularly at the south. There are reasons for regarding the trough as containing two distinct but probably connected embayments. One of these embayments extended toward the southeast in the locus of the present San Joaquin Valley, and the other toward the north, or northwest, within that of the Sacramento Valley, or beyond it.

The diastrophic records in these two embayments were not entirely coincident throughout Cretaceous time, as shown in the lack of parallelism in their respective sequence of deposits, and also in their environments, although they have much in common.

In these embayments Cretaceous deposits are presumed to fill much of the trough beneath later formations, although their outcrops are chiefly along its western or southwestern margin. No final account can now be given of either of these embayments, although it is possible to infer much concerning their records from a study of the deposits themselves and from

their environments, both about and beneath the valley floors, as shown by the drilling of deep wells.

Although few exposures of Cretaceous rocks are found along the eastern border of the trough, except at the north (Shasta, Butte, and Tehama counties), those on the western border contain much data bearing upon the physical aspects of the region during the later epochs of Mesozoic time, in part consisting of the materials of which they are composed, and in part of the fossil remains buried in them.

The Nevadian revolution which closed the early upper Jurassic (Mariposa-Mount Jura) epoch seems to have opened the succeeding Knoxville epoch, during which the position and extent of these troughs became greatly altered, and in part much restricted. As a result of this revolution the shore lines of the Maripose-Mount Jura sea were greatly changed; the marginal marine areas of the following epoch in this region were shifted, and in fact restricted to the Great Valley trough and its contemporary embayments north and south. The Knoxville inland seas entered these troughs through more restricted gateways than before; these gateways were apparently separated by recently emerged land-links, or islands. At all events, marine Knoxville sediments are now found lying along the west margins of well-developed troughs—that is, along the east margin of the front range of a large mountain area west of the Great Valley, and on the eastern borders of similar though smaller land areas farther south, and farther north, in part now occupied by Coast Ranges.

DOUBTFUL AREAS

On the older geologic maps of California (Hamilton-Smith, 1916, and others) various areas of supposed Cretaceous rocks are shown as extending along the coast north of San Francisco Bay. Only a small area (Fort Ross to Gualala) has supplied definite fossil evidence that Cretaceous deposits are really present here. The supposition that Cretaceous rocks cover these areas seems to have been based entirely upon lithological appearances, not upon fossil evidence. Reference was made by Diller (1902, p. 65) to a species of *Aucella* found on the lower Van Duzen River, but proof of its Cretaceous age is lacking, and the neighboring area should be regarded as doubtful. Other areas of buff or tawny sandstones, resembling Middle or Upper Cretaceous deposits, as known in the Great Valley, have been noted about the upper Russian River valley, in the basin of Clear Lake, on the lower Van Duzen and Mad rivers, and in the coastal parts of Del Norte County, but their assignment to any group of Cretaceous sediments should be taken as provisional only. Doubtless, some of these areas do contain Cretaceous deposits.

The State geologic map (1916) also shows a long zone of supposed Cretaceous rocks extending along Mad River to a point beyond its head,

but no proof of a Cretaceous age has been supplied for any part of this area, and the supposition of such an age may have been based only upon the note made by Diller (1902).

A small area of sandstone similar in lithologic appearance to that of the upper Russian River Valley is found on the Middle fork of Eel River, between Covelo and Dos Rios, which contains numerous Upper Cretaceous Mollusca, but its extent and thickness have not been determined. What connection it may have with any other area of Cretaceous sediments is not yet known since it appears to be somewhat isolated.

At the head of Mad River, the so-called "Shell Mountain" shown on the Forestry maps is said to contain marine shells, but these reports have been disputed, and the evidence may be regarded as nil. Small areas of supposed Cretaceous sediments have been found on the flanks of the Klamath Mountains at elevations of 4,000 feet, or more, but their occurrence at such altitudes, if they are Cretaceous, has been due to post-Cretaceous faulting and should not be taken as having any other significance.

INTERRELATION OF TROUGHS

There is at present lack of evidence that the several troughs existing in Cretaceous time in California and Oregon were closely connected, except by way of the open sea to the west. In some cases the deposits belonging to separate troughs are found to approach each other, especially those of the later epochs, but not to the point of merging. For example, there is no evidence either in the distribution of the sediments, or in the faunas contained in them, that the basins of southern Oregon had any direct connection with the basin of the Great Valley of California or with that of the Ochoco region in north-central Oregon. There was indirect connection and communication among them by way of the open sea only. All were embayments from the Indo-Pacific Ocean.

Diller at one time thought that in early Cretaceous time the areas in southern Oregon had connection with the area in the Great Valley of California by a sea-way east of the Klamath Mountains through what he termed the "Lassen Strait." No evidence has yet been offered to support the view that such a strait ever existed, but much evidence has been found to conflict with it, and Diller himself seems later to have doubted its existence, since the profound subsidence during Cretaceous time recognized by him left only later Cretaceous deposits on the line of this hypothetical strait in the Great Valley of California or on the flanks of the Cascade axis in Oregon.

Evidence of interconnection of any of the troughs farther south is largely paleontological. For example, there appears to have been connection between the Joaquin embayment in the Great Valley and the Santa Lucia trough through sea-ways at the south, or across the area of

the present Diablo Range, although their deposits are not now known to be continuous. Faulting and denudation have left them in part widely separated.

Little information concerning the marine Cretaceous channels south of the Great Valley now exists in the distribution of the deposits, apparently for the same reasons.

As in other Cretaceous areas on the West Coast, no serious attempt has yet been made to distinguish early Cretaceous from late Jurassic (Knoxville) deposits, and therefore the information actually available has not been collected or used. From our present knowledge of the structural conditions and contents of these troughs it is evident that post-Cretaceous tectonic activity has been intensive and denudation extensive in their environs. Some of these troughs are incomplete, and they appear to have been fragmented by faulting. There is also reason for believing that large land areas have been severed from the continental border since Cretaceous time by such action, although exact data as to their extent and physical aspects are not now obtainable. We are left to infer, only, from data obtained from the deposits themselves and from those of often remote parts of the coast what the physiographic conditions were during the several epochs of Cretaceous time.

As is the case in all the better-known Cretaceous areas in California and Oregon, the deposits found in the intermontane troughs at the south are almost wholly detrital; their stream-borne materials were laid down under marine conditions and within limited embayments or channels. There is a general absence of organic deposits, except fossil Mollusca, and they are not abundant.

In most of these troughs south of the Great Valley the invertebrate faunas that have been obtained represent either the early part of the Cretaceous or late Cretaceous only. Faunal evidence of deposition during intervening time (Barremian to early Albian) is meager or altogether lacking. Either such sediments were not laid down or they have been removed or are hidden beneath later deposits by overlap. The overlapping of early Cretaceous by later deposits seems to have occurred in parts of Oregon, and in fact early, and perhaps later Cretaceous deposits appear to be overlapped by Eocene deposits (Coos Bay, Port Orford, and Roseburg folios). In many such areas the absence of Horsetown deposits from the sequence is one of the most striking facts in the Cretaceous history on the Pacific Coast. In the Joaquin embayment of the Great Valley trough itself, the upper Cretaceous sequence rests for the most part upon the earliest beds of the series. Only at rare intervals have Horsetown fossils been found, whereas in most places no Horsetown sediments occur at all between upper Albian and Valanginian strata on the west border of the Joaquin embayment.

ENCLOSING LAND AREAS

General Statement.—The recognition of late Jurassic and early Cretaceous troughs and impounded sediments implies contemporary land areas from which the sediments were derived. The extent and character of these lands may be inferred from the character, structure, and content of the deposits themselves. On their continental side one may suppose that extensive land areas occupied the wide region between them and the marine Cretaceous areas in the western Interior (Rocky Mountain) regions. On the eastern side of the Great Valley trough lay the orogenic block of the Sierra Nevada, of which little is known pertaining to early Cretaceous time, since no early Cretaceous deposits appear along its western border. In the southern coastal embayments and in those of Oregon, better evidence may exist, but as yet little attention has been given to this aspect of their Cretaceous areas. Information as to the relief of these bordering land areas, their drainage lines, and their climatic conditions, must await further search and analytical study of contiguous marine or other sedimentary deposits. At present there is no evidence, in either their physiographic aspects, or in any bordering deposits, that large streams had entered the Great Valley embayments on their continental side, although it would seem from their larger areas that large streams and large stream deposits would be found here. Possibly the climatic and drainage conditions of these lands during Cretaceous time were similar to those of today, with arid climatic conditions toward the east and short drainage lines toward the west leading into the Great Valley trough.

In the troughs of southern Oregon (Riddle, Myrtle Creek, and Dillard) the immense beds of coarse conglomerate and sandstone may indicate streams coming into these troughs from the east, but the known deposits are not of the extent, position, or character that would indicate large rivers coming from the east, but rather torrential, steeply graded streams entering the troughs from other directions. No evidence is now known that any large streams entered these troughs comparable to that which entered the Great Valley of California from the west during Cretaceous time. It is only from stream-borne sediments and their organic contents that cogent information may be obtained concerning coexistent land surfaces, their physiographic conditions, geology, climate, and vegetation.

Northeast of the Great Valley trough the volcanic flows of northeastern California and southeastern Oregon have hidden all evidences of Cretaceous land in this direction, although such land must have existed here. That they supplied little, if any, early Cretaceous sediment to the embayments within the limits of California is evidenced by the absence of such deposits along the eastern borders of these troughs. This absence contrasts strongly with the presence of vast deposits of early Cretaceous sediment along the western border of the trough, especially at the north. There is

no evidence that any large stream had entered the trough from the northeast. The assumption of a marine water-way ("Lassen strait") connecting the Great Valley trough with those of southwestern Oregon during any part of Cretaceous time is unsupported by any satisfactory evidence. The same may also be said concerning the embayments of southwestern Oregon and that of later Cretaceous age along the south flanks of the Blue Mountains in northeastern Oregon. The faunas of these areas indicate no direct connection at any Cretaceous epoch. The drainage direction of the wide region to the east of the present Sierra Nevada during Cretaceous time is still unknown.

Mohavia.—The name "Mohavia" has been given by Reed (1933, p. 119) to the late Mesozoic land area south and east of the Great Valley, which, during Cretaceous time he believed:

> "was probably not very high, but was well watered, and supported several large rivers which drained westward and added great quantities of detritus . . ."

[to basins lying among the outer Coast Ranges of southern California]. The idea thus expressed indicates a possible solution of the drainage problem just mentioned. But as no important deposits are indicated as the possible drainage products of such rivers the suggestion is not conclusive. The nearest area of such sediments is in the Cuyama-Sisquoc region, Santa Barbara County, and these might be attributed to a nearer source among the neighboring mountains to the east. In view of the well-preserved and impressive river deltas (Knoxville and Shasta) in the northwest quarter of the Great Valley, described below, the limited areas and smaller volumes of Cretaceous detritus found in these southern districts do not seem important, and the rivers to which they owe their origin were correspondingly small. There is some evidence, too, that a part of the Cretaceous detritus filling these troughs came from sources toward the west and from land areas now covered by the sea. This view is supported by many geological and physiographic features of the southern Coast Ranges, the California coast, and the off-shore islands, and also by the character, and in some cases by the attitude of the strata themselves which occupy these troughs.

Salinia.—To the west of Mohavia and of these troughs, in part, were other apparently extensive land areas partly described by Reed (1933, p. 292–297) under the name Salinia. The system of mountains now partly submerged (Santa Cruz, Santa Lucia, Santa Ynez, Santa Monica, and the Peninsular coastal ranges), to which Salinia belongs, seems to represent the eastern borders of lost land areas that existed during early Cretaceous time. The areal extent of these lands is unknown, although it may be roughly indicated by the outposts of continental rocks still above water found on some of the southern islands (Santa Cruz, Santa Catalina, Cedros, and Santa Margarita), and by volcanic islands of the eastern

Pacific border. Reed has described Salinia as an ancient landmass that existed during late Mesozoic (Franciscan) time. He believed this to have been bounded on the east by the now active San Andreas fault. The area was named for "the granite 'backbone' of the Salinas Valley district and adjacent parts of the southern Coast Ranges." It is well known that most of the coastal granite areas lie west of this fault zone, and this fact may contain a hint as to the cause, or process, by which large land areas have been severed from the continent. It seems probable that during early Cretaceous time the eastern border of Salinia coincided with the southwest border of the Joaquin embayment, along the more northerly part of which there is a fringe of early Cretaceous sediments. From this zone the area of Salinia extended westward to, or far beyond, the present coast line of southern California. The southward extension of Salinia may have included the San Raphael Range and the small area of Point Sal, Santa Barbara County; between Salinia and the continental border lay a wide channel connecting the Joaquin embayment with the open sea to the south. This sea-way may have been ancestral to the "San Raphael Strait" of Tertiary time described by Reed (1933, p. 292–297).

It seems probable, also, that during early Cretaceous time other land areas intervened between Salinia and large land areas to the north, since early Cretaceous deposits containing eastward-dipping conglomerates and sandstones flank the Santa Cruz Range on the east, the early Mesozoic (Franciscan) areas of the Berkeley Hills, and those at the mouth of Russian River, farther north. Between these island areas were open sea-ways leading into the Great Valley trough and its embayments.

The coastal islands of central California during early Cretaceous time were not of high relief since the sediments left along their eastern borders are of the type which would be found at the mouths of moderate streams of gentle grade. Thicker beds with coarser pebbles are found near the mouth of Russian River and northward. In this area more recent effusions of volcanic matter have hidden much, and the underlying Cretaceous sequence can only be inferred from exposures farther north and east (Russian River Valley, Clear Lake Valley, Morgan Valley, and others).

As to the Cretaceous land areas off the coast of Lower California and Mexico, there is paleontological evidence in the faunal relations of the California early Cretaceous invertebrates, particularly those of Horsetown time, that during this epoch a littoral corridor fronting the then continental border extended far to the south, and it seems probable that a land bridge connected North and South America during early Cretaceous time and that an effective barrier far west of the present isthmus separated the Atlantic (Tethian) marine province from that of the Indo-Pacific region to which the Cretaceous faunas of California and Oregon belong.

Klamathonia.—In the region of northwest California and southwest

Oregon there are proofs on an impressive scale that during early Cretaceous, as during Knoxville time, a large land area existed to the west of the Great Valley trough. The evidence is to be seen not only in the mountainous areas of ancient rocks rising far above the sea, destitute of any truly marine later Mesozoic deposits, but even more clearly in the adjacent Knoxville and early Cretaceous deltas and current-carried deposits that can be taken only as the products of river discharge from an extensive drainage basin in this direction, such as still exists in this region in the areas now drained by its rivers.

Schuchert (1924, pt. 2, p. 195, 231, 313, 355, 425, 465, 505, 539) has depicted an ancient and partly detached landmass as having existed on the continental border here during early Paleozoic times, and to this landmass he has given the name "Cascadia" (Cascadis). For the several periods following Cambrian time he has shown changing land conditions within this region down to Mesozoic time, although for the later periods he does not continue the name "Cascadia" for any land areas. With some modification, his conception of sea and land conditions in this region during early Cretaceous time (Schuchert, 1924, p. 539) provides a convenient starting point for the present purpose. Whatever the physical conditions may have been prior to Jurassic time, it appears certain that throughout the latter half of this period a large peninsular land area occupied much of northwest California and southwest Oregon and extended westward beyond the present coast lines. For this Mesozoic land area the name Klamathonia would seem to be appropriate, although its exact limits and tectonic history are not yet fully known. On its northern and southern borders, during later Jurassic and throughout Cretaceous time, trough-like basins limited its land areas, and in some places such troughs penetrated its borders and even extended into its inner areas in one or more places.

One may believe that during Knoxville and Cretaceous time Klamathonia was a mountainous landmass, of peninsular form, whose first emergence antedated Mesozoic time and remained above sea down to the present. In the central areas of the existing Klamath Mountains, between Rogue River on the north and Clear Lake on the south, no Knoxville deposits have been found, although they appear along the flanks of the eastern front range of Klamathonia, and in some places on the west (Van Duzen and Mad rivers). North of Rogue River, Knoxville deposits occur in Douglas and Curry counties, Oregon, but, as they have not been distinguished from the early Cretaceous, their distribution is not definitely known. Within the limits of California, and particularly about the northern borders of the Great Valley, better evidence exists. It is here that the Knoxville and Cretaceous deposits have their most complete development.

The geological composition of Klamathonia and of the other land areas

bordering the embayments of Knoxville time need not be described here, although latest among these basement rocks should be included all that are properly embraced under the name Franciscan series. The recognition of a late Jurassic (Portlandian and Tithonian) age for the Knoxville implies that the closing epoch of Franciscan time was not later than mid-Portlandian and, therefore, that it was possibly synchronous with some part of the Mariposa-Mount Jura period. The next important dynamic event in West Coast Mesozoic history came at the close of Knoxville time, when distinct and widespread orogeny, whose regional or local effects are not yet fully known, seems to have affected the entire Pacific Coast.

Its movements were not everywhere the same. In the area of the larger California embayments, and in southwestern Oregon, their vertical components were probably differential. In some of the mountain areas of Klamathonia the land reliefs of Knoxville time were accentuated by uplift, with a corresponding contraction of flooded areas in the embayments. In other places land surfaces were depressed, with sea encroachment on their borders. The longitudinal extent of this orogeny is not yet known, but it appears to have reached Alaska on the north and Mexico or farther on the south.

At the close of Knoxville time the sea-ways leading into the embayments of Oregon and California seem to have been greatly narrowed and remained so throughout Cretaceous time. During this period the mountains of Klamathonia maintained their prominence, as with some modification they continue to do. According to Diller (1894), the Klamath Mountains of the present embrace most of the coastal region between the Umpqua River in Oregon and the latitude of Red Bluff, California. This should be regarded as a minimum estimate of their area. If the critical epoch between the close of Knoxville and the opening of Cretaceous time is chosen as the date for estimating the area of Klamathonia, its area would embrace the peripheral zones of all known pre-Knoxville terrains, and among them that of the Franciscan series, which in the outer Coast Ranges extends northward beyond the Humboldt Bay. Metamorphic rocks outcrop near Big Lagoon and at intervals along the coast as far north as the Coquille River. At the close of Knoxville time the area of Klamathonia may be estimated at 29,500 square miles, nearly 75 per cent of which (22,000 square miles) lay within the present boundaries of California, north of the 39th parallel. However, this estimate includes the areas still extant as land and those now probably submerged along its western borders.

There is no evidence that during any part of Knoxville or Cretaceous time the sea had covered more than small, and essentially peripheral, parts of Klamathonia, and these only in early Cretaceous time. Some of the most remarkable aspects of this mountain block appear in its

geological constitution and in the stability of its older, fundamental terrains from which has been developed its present framework, and its enclosed basins of lower relief. Although its surface features have suffered from faulting and other tectonic action since Cretaceous time, the deep-seated elements in their composition and structure still remain, and show in their character and persistence, the general outlines of Klamathonia as it formerly existed and many of its original physiographic features. The stable elements in the composition of its mountains, which primordially dominated its relief and controlled its hydrography through its early history, still remain prominent and still exert control over its drainage as they did at the end of Jurassic and through Cretaceous time. As for its drainage system, Klamathonia may be considered as constituting a crustal block, having an established drainage system, which, notwithstanding much longitudinal faulting (some of it on a large scale), many uplifts and warpings, in part or as a whole, still remains intact, although its drainage now spills over its western rim, instead of its eastern, as it did during later Mesozoic time. In its larger aspects the Klamathonia block, with great uplift on its eastern border and subsidence evident on its western side, bears much resemblance to that of the Sierra Nevada. This resemblance extends not only to its geological composition, and in part its structures, but also to its tectnoic solidarity subsequent to the Nevadian revolution. The inclusion of the Klamath River drainage with that of the Trinity River, as a source of the Cretaceous sediment in the embayment, does not conflict with the conception of crustal warping or faulting just described as causing the reversal of its drainage direction. On the contrary, it is believed to add support to the concept of the solidarity of the Klamathonia block and its tilting since Cretaceous time.

Other Land Areas.—It seems probable that in the coastal areas of central California there were islands of low relief and that more than one inlet from the sea existed here during early Cretaceous time, although in some places evidence is obscured by faulting, and in part by Tertiary volcanic effusions. Large areas of Cretaceous land, now lost, lay south of the latitude of San Francisco Bay, already described.

To the east of the early Cretaceous embayments the broken border of the continent now offers some problems. As a result of the Nevadian revolution (orogeny) land areas in the position of the Sierra Nevada extended far to the east and to an unknown distance south. Toward the northeast the volcanic flows of northeastern California and much of Oregon have hidden the evidence of lands adjacent to Klamathonia and the Great Valley trough. There is little direct evidence as to the relief of land areas that existed anywhere east of the embayments of either California or Oregon. That such lands supplied small, if any, quantities of sediment to early Cretaceous deposits seems evidenced by the fact that

no such outcrops are found along their eastern borders. Whether this lack of early Cretaceous detritus on the eastern borders of these troughs was due to limited drainage slopes leading into them from the east or to arid climatic conditions here, such as now exist, is not known. But it is possible also that faulting near the central axis of the trough during later epochs of the period, with elevation of the Sierra Nevada block, and the denudation of its early Cretaceous sediments, followed by still later subsidence and marine transgression, may have hidden evidence of their existence.

In the southern embayment of the trough the suggestion finds some support in the deep well drilled near Chowchilla, near the axis of the valley, which passed through only upper Cretaceous sediments and into basement rocks.

CRETACEOUS DEPOSITS IN THE GREAT VALLEY

From the viewpoint of historical geology, the most important Cretaceous areas in California, or perhaps in any part of the West Coast, are found in the Great Valley. Probably the greatest stratigraphic aggregate of Cretaceous sediment in North America, or perhaps in any country, is found here. It would appear that, as a source of data bearing upon the beginning and close of Cretaceous time and upon some of its major events, as recorded in its stratigraphic sequence and its faunas, the equal of these deposits has not been found in any other West Coast region. The environments of this trough have already been partially given. As for the deposits herein contained, the circumstances of their position, their attitude, character, and relationships, their protection from waste, freedom from tectonic complications, their succession of rich invertebrate faunas, and their final exposure, which is exceptional, should make them of unequalled value in supplying historical criteria bearing upon the early Cretaceous epochs and events on the West Coast. Their interest is also greatly increased by their structural and faunal relationships to the underlying late Jurassic (Knoxville) sequence and the succeeding upper Cretaceous, outcropping on both sides of the Great Valley.

In a portion of the trough, their older divisions contain a succession of marine invertebrate faunas ranging from early Valanginian to late Albian time. In other portions the record is continued almost to the closing stages of the period. In brief, there is represented in this trough nearly all the chronologic stages known in the Cretaceous succession of any country, from Berriasian to Maestrichtian time inclusive. Unfortunately, however, they are not all found in any single section, and few sections show a continuous sequence of faunas throughout their column, but in the several sections within the trough the faunal record is nearly complete, except in certain parts of its latter half. In the unusual thickness of the

sedimentary aggregates they present difficulties in the matter of correlations with other more concentrated columns in the Cretaceous deposits of other countries, but these difficulties may be more apparent than real.

EMBAYMENTS OF THE TROUGH

GENERAL STATEMENT

The Cretaceous deposits within the Great Valley trough are found chiefly on the west borders of its two major embayments, which lie in opposite directions from a supposed marine entrance to it near San Francisco Bay. These embayments may be known as the Sacramento and the Joaquin, corresponding to the major parts of the Great Valley of the present, although they are not proportional in dimensions.

In the Sacramento embayment both the physical and paleontological records for the lower Cretaceous are more complete, extending from Berriasian to late Albian time, the higher portions of the column being partly lacking, the lower portions of the sequence here constituting the Shasta series in its type areas.

In the Joaquin embayment both the stratigraphic and faunal records of the Shasta series are incomplete. At the bottom, the column begins with early Cretaceous deposits that represent a part of Valanginian time, but for the most part its areas are fragmented by faulting. Upon these scattered deposits there is a succession of Upper Cretaceous strata, occupying the span from late Albian almost to the close of the period. Between these portions of the column there is a stratigraphic hiatus, in which almost no Hauterivian, Barremian, or Aptian faunas have been found, although this condition appears to be in part due to faulting. Nevertheless, the facts seem to indicate a different sequence of depositional and of tectonic events than those found in the Sacramento embayment and suggest the possibility that the two embayments were not so closely connected during a part of Cretaceous time as the present aspect of the Great Valley would indicate.

In the Joaquin embayment the volume of later Cretaceous deposits (Albian to Maestrichtian) far exceeds that of its early portion, attaining a maximum thickness of more than 25,000 feet, although in some places it does not exceed half this thickness. The faunal sequence is much less complete than in the northern embayment, although in its upper part the faunas are better developed, whereas in its lower four-fifths the faunas are scanty and almost wholly post-Cenomanian.

JOAQUIN EMBAYMENT

General Statement.—The view that the principal portal leading to the Joaquin embayment was near San Francisco Bay may not be wholly correct since it does not meet all factual requirements, especially for the later Cretaceous deposits. These Cretaceous beds outcrop only along its

western border—that is, along the east flanks of the Diablo Range which they dominate for nearly 200 miles. The width of their zone is from 1 to 12 miles along this range, being widest in its central part and broken by faulting at the north and south. The stratigraphic thickness of the succession varies from 1000 to more than 25,000 feet. Sections showing a thickness of 17,000, 20,000, and 23,000 feet were first observed by Brewer (Whitney, 1865a, p. 40–46) in the northern part of the range, but later estimates of strata exposed in the Panoche Hills district have given a maximum of 25,000 feet. South of these hills sections described by Anderson and Pack (1915, p. 36–40) show a diminishing thickness. Sections in the northern part of the range consist largely of conglomerates and sandstones, as described by these writers and by others, and in many places they form the middle part of the sections (Panoche Hills and Ortigalito Creek). The lithological sequence of beds varies in different districts. Finer sediments predominate at the south, and coarser materials at the north (Puerto Creek). West and northwest of Coalinga, shales constitute a large part of the sections, but conglomerates and sandstones are prominent near the base in the Waltham Creek Valley and northward. Lower Cretaceous strata crop out only at intervals (Mount Diablo, Quinto Creek, Waltham Creek, and Orchard Peak), but they are neither prominent nor continuous, although thick at the north and at the south.

The larger part of the succession in the Diablo Range is made up of Upper Cretaceous deposits (Cenomanian and later), which in some places attain a thickness exceeding 25,000 feet. This succession is divisible into groups of strata, though not of equal thickness. The lower portion has thus far supplied few diagnostic fossils, yet enough to prove a stratigraphic range from lower Cenomanian to uppermost Turonian. The maximum thickness of this group is probably as much as 7000 feet, and it may be more. Shales predominate in many of its exposures, as in the vicinity of Mount Diablo.

Above the lower group there is a sequence of strata having a maximum thickness of 16,000 feet, outcropping north of Mount Diablo, and in the Diablo Range farther south the thickness is somewhat less.

At the base of this sequence are thick conglomerates, as in the Panoche Hills, on Quinto Creek, and farther north, which appear to indicate unconformity upon the earlier group. Above these conglomerates lower Senonian (Coniacian) fossils have been found, and in the upper part of the sequence rich faunas of upper Campanian age are abundant. Still higher in the sections there is a thick group of strata which includes the partly organic (Moreno) shales, and which attains a thickness of 5000 feet or more. The upper part of this group consists of fossiliferous sandstones, as on Garzas Creek, and farther north.

The structural attitude of the Cretaceous succession in the Diablo

Range is entirely monoclinal, flattening eastward toward the Great Valley. The strike of the strata is for the most part parallel to the course of the range, and their dip is eastward at inclinations varying from nearly vertical at the base to nearly flat on the margin of the valley, beneath which they seem to pass.

In the vicinity of Mount Diablo the Cretaceous beds are greatly disturbed, often faulted, and in places overturned. In the districts east and north of Mount Diablo the general strike of the beds turns from northwest to nearly west, and the succession becomes broken by faulting, and detailed mapping is difficult.

As the deposits in the Joaquin embayment belong for the most part to later, rather than to early, Cretaceous time, a more detailed study of their divisions and other features is left for future consideration. The problems involved in the sedimentation and faunal changes in the Upper Cretaceous of the West Coast are distinctly different from those of the earlier half of this period.

Sources of Sediment.—Concerning the sources of the Cretaceous sediment now found along the western borders of the Joaquin embayment, little can be said at present. The position of these sediments, the attitude of the strata, their lithological composition, and order, would all point to mountainous land areas toward the west as the source from which they came, and no other direction or source seems admissible. Yet, up to the present, little attention has been given to this phase of the subject. No evidence has yet been offered to indicate that land areas of great geographical extent had existed in this direction in Cretaceous time. If mountainous areas commensurate with the deposits themselves had existed here, they have suffered loss. It is known that the region south and west of the Joaquin embayment contains areas of highly folded Tertiary strata and is traversed by lines of major faulting, and that the movements that have resulted in these foldings and displacements were post-Tertiary. These movements must of necessity have also involved Cretaceous and older terrains and correspondingly reduced the land areas of the past. From this viewpoint it should be seen that the land areas of Cretaceous time have suffered much compression and much loss from faulting and displacement and are now only partially represented by existing mountain areas toward the west. The character of the material constituting these Cretaceous deposits indicates mountainous areas of ancient rocks (schists, quartzites, and crystalline eruptives), and the volumes of these sediments indicate the same. One may also infer from an analytical study of these deposits that these land areas were large and that the streams that carried their detritus were large and their drainage areas great.

Nevertheless, in comparison with the sediments of the Sacramento embayment and the drainage areas that supplied them, also toward the

west, those adjacent to the Joaquin embayment seem relatively small and unimportant.

SACRAMENTO EMBAYMENT

In early Cretaceous time the northern embayment of the Great Valley trough extended from its major outlet near San Francisco Bay toward the north, or northwest, not only to the present extremity of the Great Valley, but far beyond it toward the west, and penetrated the interior of Klamathonia. More definitely, it seems to have reached a considerable part of the basin area of the modern Trinity River and to have received waters from far beyond it, to the west and north. Cogent evidences of these conditions are to be seen in the residual outliers of Cretaceous sediment, marine, partly marine, or of brackish character, still extant, detached from the main embayment, and scattered about the areas of this basin. This arm of the Sacramento embayment existed under marine, or partly marine, conditions only in early Cretaceous time (pre-Horsetown). During part of the Horsetown and subsequent epochs marine waters were withdrawn from it, presumably as a result of uplift in restricted mountain areas surrounding its area.

CRETACEOUS DEPOSITS

General Statement.—The Cretaceous deposits of the Sacramento embayment have been more extensively studied than have those of the Joaquin embayment, but they are still only imperfectly known. Within the limits of the Great Valley, the oldest Cretaceous deposits appear to rest in some places in sequential contact upon those of the latest Jurassic (Knoxville) epoch, whereas in other areas this is clearly not the case. In the intermontane extension of the trough, the oldest Cretaceous beds rest directly upon pre-Knoxville basement rocks, in the manner of an overlap, with no Knoxville sediment intervening, and this condition is also found in other areas farther south.

In this more restricted embayment the Cretaceous deposits outcrop in two marginal zones on opposite sides of its general valley, but they are of quite unequal stratigraphical thickness and areal extent and are for the most part of different ages.

In the northern end of the Great Valley trough, north of the latitude of the 39th parallel, the Cretaceous deposits outcrop in two marginal zones on opposite sides of the valley, in which they are of quite unequal thickness; for the most part they belong to different epochs of Cretaceous time. The eastern zone is of relatively small stratigraphical importance, as well as in its exposed areas. Its deposits belong to only Upper Cretaceous horizons, as do most of those in the Joaquin embayment, in which beds older than Cenomanian are not found. For the most part these are buried under volcanic agglomerates, which permit their exposures only at

intervals along the foothills of the Sierra Nevada where modern streams have trenched them (Pitt River, Cow Creek, Oak Run Creek, Chico Creek, Butte Creek, and others), or where local uplifts (Tuscan Butte and Sutter Buttes) have brought them to the surface. These exposures have been partly described by Diller, Fairbanks, Williams, and others. The maximum thickness of these deposits does not exceed 3,000 feet and is generally less. Where their basal contact has been found they rest directly upon pre-Cretaceous formations (Pitt River, Cow Creek, Butte Creek, Pentz, and Folsom), and this condition appears to be general. In the Joaquin embayment no Cretaceous exposures are known on the eastern side of the trough, although Upper Cretaceous strata have been penetrated far below the surface (Oakdale and Chowchilla).

Neither Knoxville nor Lower Cretaceous deposits have been found along the foothills of the Sierra Nevada, nor has deep drilling on this border of the Great Valley revealed any, although basement rocks have been reached in the Chowchilla well. No lateral or minor indentations of the trough have been found on this side of the Great Valley, which may be interpreted as the locus of a large stream entering it from the east, except that of Pitt River, during a late Cretaceous epoch. The absence of Knoxville and Lower Cretaceous deposits on the eastern borders of the embayments contrasts strikingly with their great development on the west, as the absence of drainage inlets on the east contrasts with the great extension of the Sacramento embayment on the west.

On the western border of the Sacramento embayment the Cretaceous deposits are much thicker than they are on the east, and their exposures are more continuous. Here they lie along the east flanks of the older mountains from Shasta County on the north to the Straits of Carquinez at the south, and far beyond, although not continuously.

On the western border of the Sacramento embayment these deposits include lower, and, in part, Upper Cretaceous strata, although they occur in quite unequal proportions. North of Fairfield their outcrops cover a zone varying in width from 2 to 20 miles. In most sections the deposits have a thickness of more than 20,000 feet. Probably the thickest succession of these sediments, although not completely exposed, is found in the drainage areas of the Cottonwood Creek and its several branches. In this area the sections vary from less than 1000 feet to a maximum of nearly 35,000 feet, as near the Shasta-Tehama County line. The thickest section of these deposits is near the Middle fork of Cottonwood Creek. Between Rosewood and the nearest outcrop of basement rocks to the west, a more accessible but slightly thinner section has been repeatedly measured and carefully studied. Its Cretaceous strata in almost regular sequence have an aggregate thickness of 32,000 feet, including about 8000 feet of Upper Cretaceous (upper Albian to Turonian) beds. The basal

portion includes the lowest strata that can be assigned to the Cretaceous system.

North and south of the line of maximum section the thickness diminishes, more rapidly toward the north, more gradually toward the south (Profile charts, fig. 1).

Along Roaring River, 5 miles north of the line of maximum section, the thickness is 16,000 feet. From here the thickness drops to 10,700 feet on the North Fork, to 5000 feet on Hulen Creek, and to less than 1000 feet on Clear Creek. This diminution is partly due to an overlap of the later beds upon the basement rocks along the contact line as followed eastward.

Toward the south the drop in thickness is less rapid. Along Redbank Creek, 16 miles south of the maximum section, the thickness is still more than 23,500 feet, and on McCarthy Creek, 15 miles farther south, the thickness of the Lower Cretaceous beds alone exceeds 13,000 feet. If to this figure is added 4500 feet, representing the Chico beds exposed a few miles to the north, the total thickness will be 17,500 feet. Farther to the south the thickness is less, but it has been measured only in part and in certain sections. More than 90 miles south of McCarthy Creek, and 125 miles south of the maximum section, the succession to the west of Winters extending across the Berryessa Valley near Monticello, eliminating all structural duplication, has a thickness of not less than 21,500 feet, including about 12,000 feet of upper Cretaceous beds (Cenomanian to Turonian), referable to the Chico series.

South of the Berryessa Valley the structural conditions of the Cretaceous sequence become more complicated and its stratigraphical thickness is less easily determined. Estimates of only the Upper Cretaceous strata have been made, and these only at wide intervals. North of Mount Diablo, estimates of the upper Cretaceous strata only show a thickness of about 21,000 feet.[1]

Volume of Sediment.—From the data at hand it is possible to approximate the cubic contents in the western zone of the Cretaceous in part. Assuming that the average thickness of the succession, as shown in the several sections, continues beneath the floor of the valley to its axis along the Sacramento River, and that from this line the average width of the area is not less than 24 miles, the cubic contents of the zone between Berryessa Creek and Roaring River would be slightly more than 13,400 cubic miles of sediment. More than 35 percent of this volume lies north of the south line of Tehama County, within a longitudinal distance of 36 miles. These figures reflect the greater thickness of the sections at the north, namely, in the vicinity of the Middle fork of the Cottonwood Creek. These estimates do not include the volume of sediment, probably very great, that has been lost from its original mass by denudation since

[1] B. L. Clark: *oral communication.*

the close of Cretaceous time, nor that carried away during deposition and not left within the embayment or along its borders.

Structures.—The structural features of the deposits on the western border of the Sacramento Valley are generally simple, although in some districts they are complicated by folding or faulting. North of the latitude of Paskenta the attitude of the beds is monoclinal, the strike being generally parallel to their western margin, and the dip normally toward the valley floor, at angles varying from 10 to 60 degrees, the average being about 30 degrees. There is comparatively little faulting within this portion of the zone, although displacements have been found south of Beegum Creek, on the Middle fork of Cottonwood Creek, and near Duncan Creek, but in no instance has any serious structural complication resulted. In western Glenn County, in the broader area of the zone, to the west of Willows and Maxwell, strike folding and faulting are conspicuous in the upper part of the sections, and here a broad synclinal fold is bordered on the east by an equally conspicuous fault zone, having a downthrow on the west and possibly a limited thrust from the east. To the north of Paskenta this condition is not found, the structure of the beds being entirely monoclinal.

The syncline just described extends for 30 miles, its axis being nearly parallel to the border of the valley; to the north and south the structure merges into monoclines. In western Tehama and southwestern Shasta counties transverse faults of small displacement are frequent, but for the most part they cannot be followed far. In a single transverse zone near the Middle fork of Cottonwood Creek, such faulting is found on a larger scale, but the displacement is distributed on a number of parallel lines. In many places the transverse fractures are filled by sandstone dikes varying in thickness from a few inches to 5 or 6 feet. In most instances these dikes are vertical or stand at a high angle, their strike being more or less transverse to that of the strata penetrated.

Areas of greater disturbance and of structural complexity are found south of the Berryessa Valley, or between Monticello and Mount Hamilton. This area includes the districts around San Francisco Bay and about Mount Diablo. This portion of the western zone may be regarded as an area of tectonic weakness, even during Cretaceous time, which continued, however, long after the close of the period. In this area both strike-faults and folds, some on a large scale, are frequent, as a result of transverse thrusting from the west.

Small overthrusts and overturns of strata have been noted in various places; most of these are believed to be post-Tertiary, although some are probably inter-Cretaceous. Many evidences of inter-Cretaceous disturbances are found in the Diablo Range, most of which are found in the Upper Cretaceous sequence.

Character of Deposits.—The Cretaceous deposits on the west border of the Sacramento embayment are almost wholly detrital sediments of stream transportation, derived from land surfaces of the period; they were laid down in the embayment under marine conditions, or in part semi-marine conditions near the point of river discharge. In this respect the deposits contrast strongly with contemporaneous deposits found in the interior province (Texas and Mexico), as noted by other writers.

The border deposits of the Sacramento embayment include the usual types of detritus, such as conglomerates, sandstones, and shales, as have been already noted, described, and illustrated by various geological writers. Only a small or negligible part of the sediments are of an organic nature, although there are local limestones, and none that can be called land-laid, or of fresh-water deposition, except those found in the basin of the Trinity River, already noted. The lithological character of the sediments, for the most part, is such as to confirm the views already suggested, that their source lay toward the west, in the areas among the mountains of Klamathonia.

It has been claimed that, on the whole, these deposits are "arkosic, that is, derived from granite" (Becker, 1888), but evidence of such origin is generally lacking. Little or no evidence has been found in the conglomerates of the Cretaceous to support the view, since granite pebbles seldom occur in them, although other types of crystalline rocks (porphyrites, gabbros, and pyroxenites) and metamorphic classes are frequently found in them, but they are not conspicuous. Limestones, such as characterize contemporary deposits in the interior province (Texas and Mexico), are conspicuous by their absence. Local thin lenses of limestone are found at, or near the base of, the Shasta series, but they are sporadic in both California and Oregon (Berryessa Valley, Wilbur Springs, Cold fork of Cottonwood Creek, and Dillard). Argillaceous shales predominate in many sections; in other districts sandstones form a large part of the column, or locally there are thin-bedded alternations of shale and sandstone. Of greater importance in marking diastrophic changes in the sequence are the conglomerates found at intervals along the zone of outcrop through several counties on the western border of the Sacramento Valley.

In some areas they are of great thickness, occurring at the base and also higher in the section (basal Horsetown). In many places conglomerates form the basal beds of the larger stratigraphic groups throughout the general Cretaceous succession. This aspect of their occurrence has usually been overlooked; a closer study of the occurrence and character of these conglomerates should bring to light many important incidents in the diastrophic history of these deposits and of their hinterland as well.

Although the basal conglomerates of the Shasta series often contain pebbles and boulders derived from the underlying Knoxville, as shown

by fossils, there is a lack of material in them traceable to the Franciscan series. In most places on the zone of contact the Franciscan rocks were apparently absent from the basement complex.

Summary of Strata.—In the foregoing statements as to the thickness and extent of the sediments on the west border of the Sacramento embayment few references have been made to the portions of the Chico series later than Turonian. In the section west of Winters, Yolo County, strata referable to the Chico series show a thickness of 12,000 feet. Later Cretaceous (Senonian) beds were not included in the estimate of 21,500 feet for this section. Later beds, including strata from Coniacian to upper Senonian, are found farther north on both sides of the Sacramento Valley, but they cannot be considered here; they will be discussed later.

Estimates (in feet) of the minimum, maximum, and average stratigraphic thickness of Cretaceous sediments exposed on the borders of the Great Valley may be summarized as follows:

	Minimum	Maximum	Average
Chico series	5,700	26,600	16,150
Shasta "	11,200	26,800	19,000
		53,400	35,150

From these figures it will appear that the thickest succession of West Coast Cretaceous deposits yet recorded is found on the west borders of the Great Valley embayments in California. Such aggregates of strata could accumulate only under unusual circumstances of climate, environment, and deposition, or of all three.

Conditions of Deposition.—It is evident that the Cretaceous deposits here described have been built up under conditions of prolonged and, in effect, continuous subsidence. It may be inferred that this subsidence had been most active near the axis of the trough and from this point would have diminished gradually toward its borders. This seems to have been the view held by Diller regarding the northern embayment, as illustrated in the sections drawn by him representing the stratigraphic succession on the western border of the Sacramento Valley. From Diller's (1894, p. 457) account of this valley we quote:

> "In accordance with isostatic conditions of the earth's crust, it would be expected that the loading region—that is, the Sacramento Valley, would sink, while the unloading region—that is, the Sierra Nevada and Coast Range, would gently rise, and in this way the enormous difference of elevation at the close of the Shasta-Chico period would easily be accounted for by supposing a much smaller original difference at the beginning of that period."

The "difference of elevation" in this text seems to refer to the bottom and top of the "Shasta-Chico series," as understood by him.

Since only Upper Cretaceous deposits are known on the eastern border of the Great Valley, it is not evident that the Sierra Nevada took much

part in these isostatic readjustments. The subsidence may be assumed to have extended with some modification into Joaquin embayment as well, and the record of its deposits, as here interpreted, shows that it did so, but not wholly in coincidence with that of the northern embayment.

Limits of Subsidence.—No evidence has been found in the deposits of the Great Valley, or in their environs, showing that the subsidence had been so profound, or laterally so extensive, as to submerge the Coast Ranges, except to a limited extent along their borders. Movements in other parts of the West Coast, coincident with this subsidence, were undoubtedly felt, since contemporary deposits are found at many places on the coastal border, but they were not of the same vertical extent. However, in both embayments in the Great Valley, as soon as accumulation of sediment began, it would at once become the cause of further subsidence, and erosion and removal of materials from the land surfaces would be an isostatic cause of their elevation. If the Coast Ranges, or the whole of Klamathonia, continued to "gently rise" they could not at the same time become submerged, and if submerged at any time during the Cretaceous period they could not have been the source of the sediments described herein.

These general facts should apply to all the troughs and should prove that subsidence would probably be confined to them. Such operations seem to have extended to all such troughs along the coastal border from Alaska to Mexico, or farther. If, at some points in the Coast Ranges, Cretaceous deposits are now found at elevations of 4000 feet, or more, the fact should be attributed to faulting subsequent to deposition rather than to a regional subsidence during the period.

Sources of Sediment.—An assumption that large land areas had existed east of the Great Valley trough in Cretaceous time has led some writers to suppose that the sources of these sediments lay in that direction, and undoubtedly a minor part of them may be traced to land areas in this direction. It would be difficult to show, however, that any considerable part of the sediments now found on the western borders of the Great Valley embayments had entered it from its eastern side. No evidence has been found that any large stream had entered the trough on its eastern side during the earlier half of Cretaceous time, and no early Cretaceous deposits are now found there. Only on its northeastern border, and during later Cretaceous time, has any evidence of such a stream been recognized—that is, in the region of Pitt River.

On the contrary, thick deposits, already described, are found on the western borders of these embayments, and at least one important river system leading into it must be recognized, as already pointed out, namely that coming from the interior of Klamathonia. But in addition to this there were many smaller streams coming from the same direction.

In discussing the physiographic aspects of this region during Cretaceous time, Diller (1893, p. 205–224) says, in part:

"Near at hand, too, by the present streams, there are coarse shore conglomerates, including gravels of the Cretaceous streams that flowed down from the Klamath Mountains on the northwest into the ancient bay of the Sacramento Valley, and one is surprised to find some evidence that the valleys of the embouching streams of early Cretaceous times are still occupied by streams."

Although Diller did not indicate the location of these streams, many carry their own evidences of these facts. Their aggregate contributions of sediment to the western zone have not been great as compared to that coming from a single river system, but their historical significance is of great interest. As many as four such streams are to be seen within a distance of 20 miles to the west of Ono, Shasta County. Others may be seen farther south along the west border of the Sacramento Valley, some of them carrying at present a considerable volume of water.

The vast volume of sediments outcropping on the west border of the Sacramento embayment should make it evident that it could not have been derived from local sources. In western Tehama County and southwestern Shasta County, north of Thomes Creek, in an area into which no large streams now enter, the volume of Cretaceous sediment exceeds 4900 cubic miles, without including that carried beyond the limits of this area during the time of deposition. This volume of material is obviously the work of a large river system draining a basin of proportionate dimensions, as is indicated also by the character of the sediments themselves and by other attendant circumstances. If this drainage area be assumed to have been 2800 square miles, it would require the removal of nearly 1.8 vertical miles of surface materials from the whole of it to produce the sediment now found within the western zone north of Thomes Creek. The volume of sediment lost from this area by denudation since Cretaceous time is, of course, unknown, but this is not a part of the present problem.

The drainage of the present Trinity River system approximates 2800 square miles. It is not necessary, of course, to assume that the volume of sediment computed for the area north of Thomes Creek came exclusively from the basin of Trinity River. Under the physiographic conditions assumed for this region during Cretaceous time, one may suppose that the valley of the Klamath River and its many branches had been at that time tributary to the Trinity River, and thus the drainage area of the latter would have been about doubled.

The drainage area of the lower Klamath River, west of the eastern outposts of Klamathonia, near Mount Shasta, covers about 2500 square miles. The combined area would accordingly approximate 5300 square miles, and the amount of denudation necessary to produce the sediments within the designated area would be correspondingly reduced, or fall within the limits of 5000 feet vertically. Denudation would not, of course,

be equal over the entire area but would be greater in some places than in others and include the erosion of stream valleys, as it does at present.

The Klamath Peneplain.—Diller (1902, p. 65 *et seq.*) has described the Klamath peneplain as extending over a large part of the region embraced in Klamathonia. This plain, which is now much dissected and deeply trenched by modern streams, is of relatively uniform relief and is developed well below the summits of the higher mountain ranges surrounding it, and of some within it. Its general elevation is between 3500 and 5500 feet above the sea and includes many plateau-like surfaces of about 4000 feet elevation, partly within the basin of the Trinity River and partly within the ancient valley of the Klamath River. Although Diller supposed the development of this peneplain to have been within late Tertiary (chiefly Miocene) time, it seems more probable that it owes its origin to Cretaceous rather than to Tertiary denudation. One large segment of this peneplain lies immediately east of the South fork of Trinity River, and others extend along the valley of the Klamath. One is to be seen to the east of Eel River, but this may have had a westward drainage in Cretaceous time. Within the areal limits of the inner peneplain are several local basins of lower altitude, containing remnants of early Cretaceous detrital deposits, marine, or partly brackish water (Big Bar, Rattlesnake Creek, and Redding Creek), and others of Tertiary age, and of lacustrine character (Hympom and Hayfork valleys). These Tertiary deposits are not thick or extensive, and Tertiary denudation and erosion have not been sufficient to remove all the early Cretaceous sediment from the general basin.

YOLLA BOLLY BASIN

In an earlier paper on the physiographic aspects of this region the writer (Anderson, 1902b, p. 144–159) suggested that during Cretaceous time a part of the basin of the Trinity River had drained eastward into the Sacramento Valley. Later investigation has found evidence that throughout both Cretaceous and Knoxville times no other outlet had existed and that the entire drainage from this basin and its tributaries had found exit toward the east. This fact is seen in the vast deposits of sediments belonging to both series on the western border of the Sacramento Valley that could not have come from any other source. This view also implies, as a corollary, that the present westward drainage from the basin by way of the Klamath River has been of later origin and probably is a result of mid-Tertiary faulting, warping of the Klamathonia block, or both. But there are other cogent evidences of the action of both these processes, partly in the faulting visible on the eastern border of the block, and partly in the evidences of subsidence on the west.

In order to distinguish the Mesozoic drainage system from the modern,

the name Yolla Bolly River (and Basin) seems to be appropriate, and is here used.

Post-Knoxville subsidence admitted marine waters into the basin from the east, and early Cretaceous (Paskenta) deposits were laid down in it. Materials were brought in by streams from the surrounding mountains, then being denuded and peneplained. The outward drainage passed eastward into the Sacramento embayment as it had done during Knoxville time. Apparently this condition continued only during the earliest Cretaceous epoch. At the beginning of the Horsetown epoch an uplift affecting the Yolla Bolly basin expelled the marine waters from it, while active erosion continued, by which a part of the earlier sediment was removed. This uplift left the strandlines of the early Horsetown epoch in the position where they are now found on the western border of the embayment, as is shown later. Only remnants of the early Cretaceous sediment now remain in the Yolla Bolly basin. The molluscan fossils found in these deposits have been partly described by Stanton and partly by the writer in the present paper.

These fossils clearly ally the Yolla Bolly sediments with the Paskenta deposits in the Sacramento embayment. Incidentally they show also that the marine currents from the embayment entered this now detached basin, bringing with them the molluscan fauna.

The most westerly of these residual deposits contain many fossil land plants and species of marine, partly marine and brackish-water Mollusca (*Aucella, Cyrena, Astarte, Corbula, Goniomya*, and *Unio*), some of which are herein described.

From a study of the present environments of this basin and their geological constitution, one may approximate the boundaries and extent of the areas from which came the masses of the Knoxville and Shasta sediment now lodged in the area into which this drainage discharged. Much of this basin lay between the massif of the great Trinity Range on the north (maximum elevation 10,000 feet) and the almost equally impressive cluster of the Yolla Bolly range on the south (elevation 8500 feet). These ranges, with their cores of ancient crystalline rocks may be regarded as parts of the north and south rims of the Yolla Bolly basin during late Mesozoic times. Its western rim is less easily shown, but in part it seems to be represented by the high, plateau-like mountain cluster dominated by Lassic Peak, south and west of the upper branches of the Van Duzen and Mad rivers. From this cluster, ribs of metamorphic and crystalline rocks extend toward the north and northwest, appearing on the present coast near Big Lagoon and along the West fork of the Trinity River.

In an earlier paper the writer (Anderson, 1902b) called attention to two great systems of mountains within the Klamath complex, the older trending northeast to southwest, and the younger at right angles to this direc-

tion. The Siskiyou, Trinity, and Yolla Bolly ranges belong to the older and more stable of these systems. The mountains on the western border of Klamathonia, constituting the west rim of the Yolla Bolly basin, may have belonged to the later and less stable of these systems. The breaking down of this western rim in post-Cretaceous time and the consequent reversal of the drainage direction into the modern system were probably due in part to crustal warping, or subsidence at the west, but in part it was due to the now well-known faulting and uplift on the eastern rim of the Yolla Bolly basin since Cretaceous time. The exact locus of the western rim of the basin is not known. Whether it had direct closure against the western end of the Trinity Range, or whether it closed against the equally old Siskiyou Range, is yet to be shown. Assuming the latter and more probable alternative, it will appear that during Cretaceous time, as during the Knoxville, that portion of the Klamath River system lying within the limits of Klamathonia, at least, was tributary to the Yolla Bolly basin, and its drainage passed into the Sacramento embayment. It may also be seen that the assumption of a connected drainage area west of the present coast line, now lost, although justified upon other grounds, is unnecessary for providing an adequate source for the sediments outcropping on the western border of the Sacramento Valley. However, since this basin is clearly the source of the Knoxville, as well as of the Cretaceous sediment, it may well have had its origin in the Nevadian revolution, and the view is supported by many geological facts that cannot be given here. It might also be suggested, *in extenso*, that the more shaly character of the Knoxville sediment may be taken as evidence of lower relief in this region during late Jurassic time, and that the river then issuing from the basin carried larger percentages of silt and clay than at a later (Cretaceous) time. It could also be supposed that Cretaceous deposition began at an epoch of uplift of the mountain areas enclosing the basin, accompanied by subsidence of its floor and of much of the floor of the Sacramento embayment. Thus, the early Cretaceous sediments were laid down in the basin upon basement rocks, whereas, in the greater embayment they were spread upon Knoxville deposits already consolidated. The distribution of the sediments constituting the two series and their stratigraphic relationship clearly harmonize with this view.

YOLLA BOLLY DELTA

The Cretaceous deposits on the western border of the embayment occupy at the north a wide re-entrant area in the coast line of Klamathonia, with its apex pointing toward the west. The sides of this area impinge upon ancient crystalline and metamorphic rocks. From this apex the sediments spread fan-wise toward the central parts of the embayment, forming here a wide expansion, but narrowing gradually toward the south (Figs. 1 and 2).

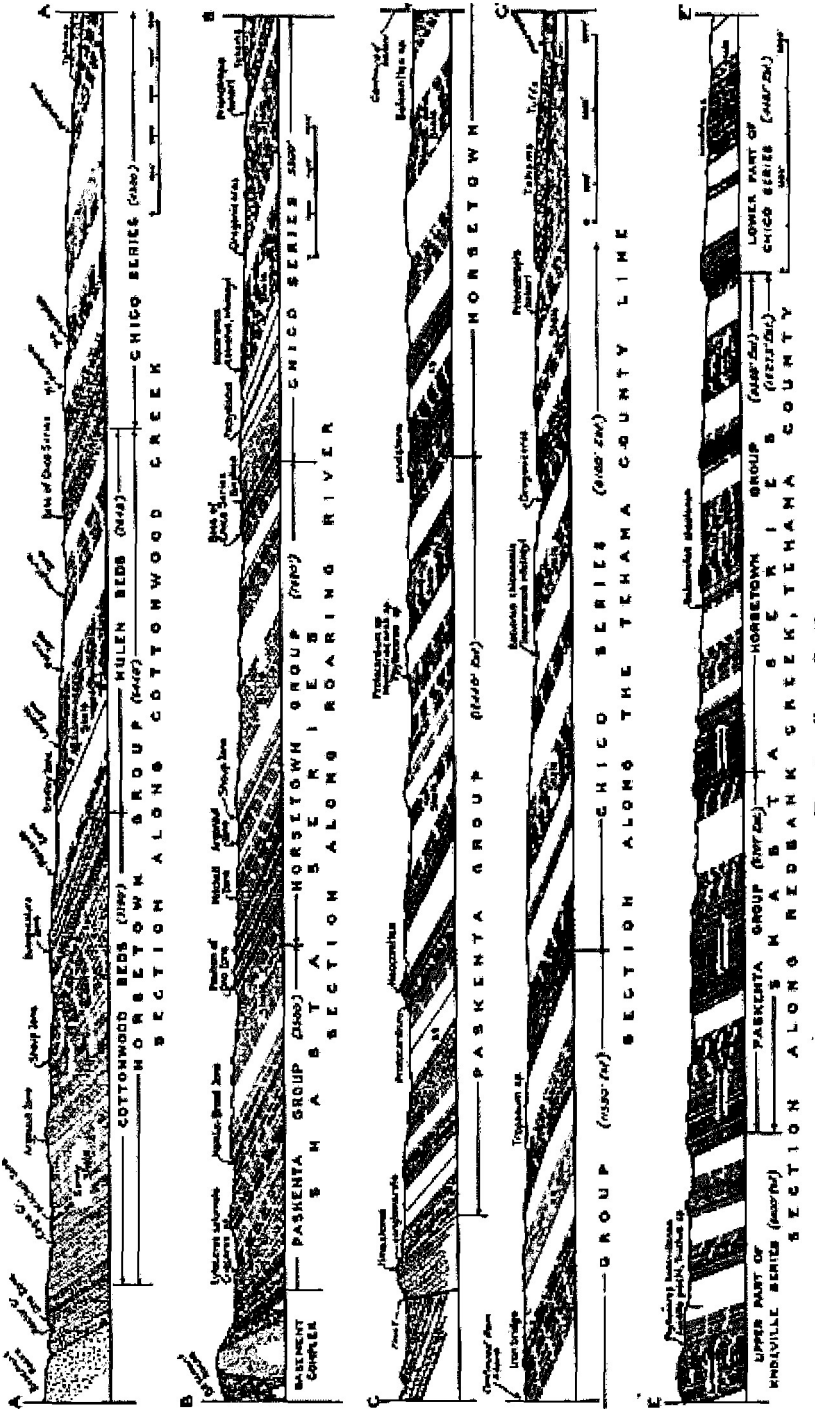

FIG. 1.—*Cross Sections*

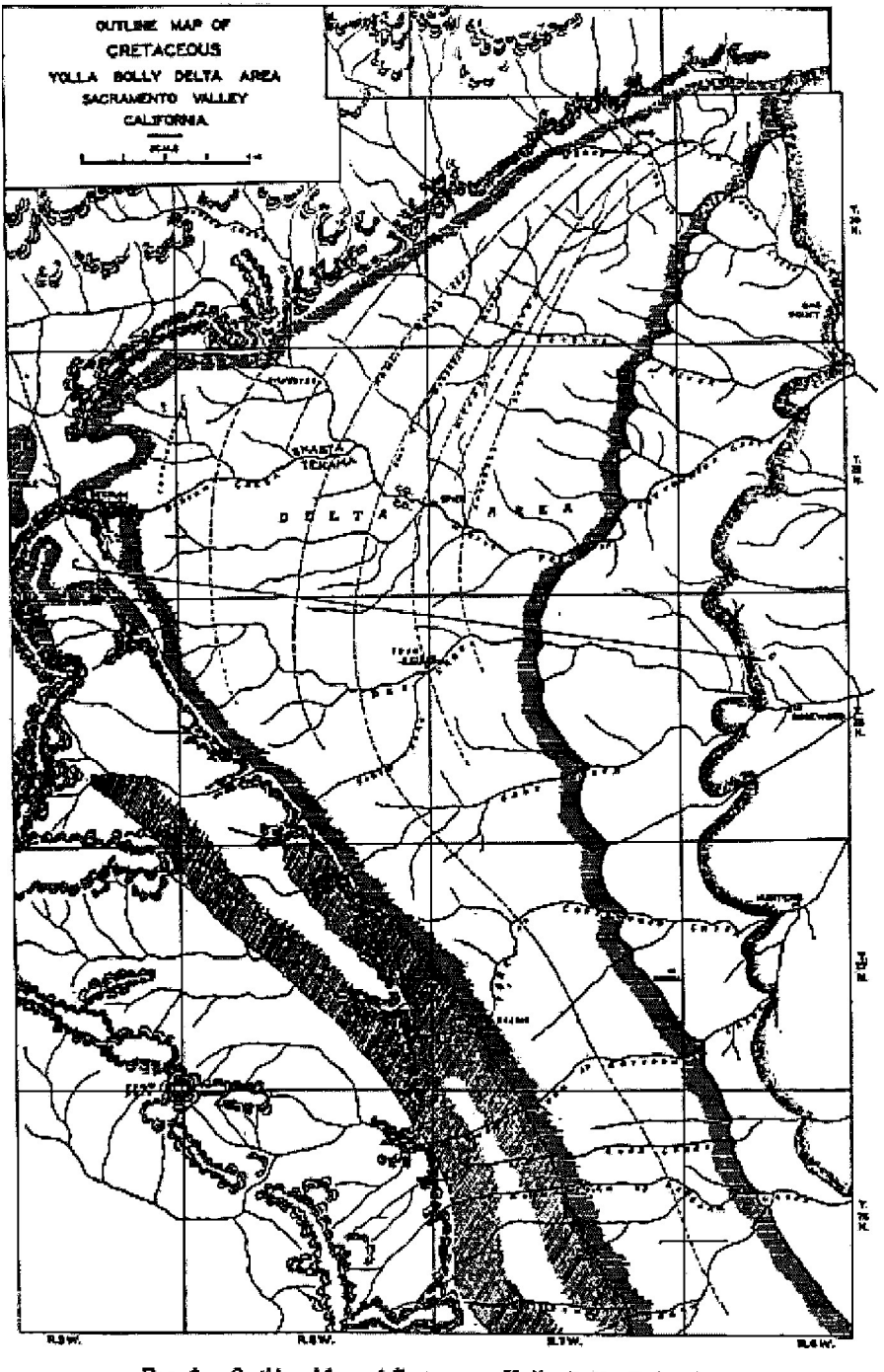

FIG. 2.—*Outline Map of Cretaceous Yolla Bolly Delta Area*

This area is not only delta-like in form, but a closer study of its structure, character, volume of sediments, and other features show that it represents the delta of a large river entering the embayment here during Cretaceous time. A study of the several sections across its area and its contained faunas, and their relationships, leads to the same conclusion, namely, that this area contains a typical marine delta developed about the debouchure of a large river entering here from the mountainous region to the west. The axis of the delta lies near the position of the Shasta-Tehama County line, and in part it is traversed by the Humboldt road between Red Bluff and Beegum.

Although the exact position of the outflowing stream is now obscure, various aspects of the topography, basement rocks, and the sediments themselves, indicate that it lay near, or slightly north of, Beegum Creek, or Beegum Peak. The sections show a decreasing thickness of Cretaceous deposits to the north and south of this line, thinning more rapidly toward the north and less rapidly toward the south.

The oldest Cretaceous beds in this area include coarse, pebbly conglomerates and sandstones about this apex, overlaid by sandstones and coarse, sandy shales washed free of clay and finer silt. At higher levels in the sequence, 4000 to 6000 feet above the base, there is a larger percentage of shales and mudstones, in conformity with the normal order of sedimentation. Marine fossils, elsewhere plentiful in this area, are rare in all parts of the sequence near the axis of the delta. No molluscan fossils have been found in the lower beds, but, 3000 to 4000 feet above the base, a small form of *Protocardium* and a small neocomitid have been found. At a still higher level, 11,000 feet above the base, were found many examples of *Protocardium*, a small specimen of *Phylloceras*, and fragments of ammonoids, all of which were rare. Still higher in the section fossils are more frequent, but not plentiful. In the lower half of the sequence only such species have been found as seem capable of a short existence in brackish water, or such as may have drifted here from other places. These forms include none of the larger ammonoids or other marine species that are abundant in contemporary beds a little to the north or to the south. In this axial area, along with a scanty molluscan fauna, are much vegetable debris, finely divided leaf remains, specks of carbonized wood, and, less frequently, pieces of poorly fossilized wood. Toward the south, along the direction of drift, plant remains are more abundant, especially in the lower parts of the sections, near the base of the Shasta series. From some of these lower beds many plant species have been obtained as identified by Knowlton (Diller, 1908), of which Diller gives a considerable list. These may be regarded as drift materials brought into the embayment by the river, carried southward by its normal currents, and dropped at points where the currents were checked by inflowing tides or other causes.

The scattered areas of Lower Cretaceous sediments lying within the Yolla Bolly basin, now detached from the body of the delta, and beyond the present drainage divide contain much corroborative evidence as to the source of these plant remains. The more westerly areas (Big Bar and Forest Glen) contain not only similar plant remains but also the marine, partly marine, and brackish water Mollusca already mentioned. Diller, who has studied these areas more extensively than any other writer, compares the deposits of Big Bar and Rattlesnake Creek (Forest Glen) with those at Redding Creek, eastern Trinity County, and considers them to be referable to the "top of the Knoxville or bottom of the Horsetown." Both these horizons seem to come within the limits of the lower Shasta series of the present paper. The Redding Creek area has yielded many species of marine Mollusca that prove its lower Shasta age and many plant remains, concerning which Knowlton remarks, in part (Diller, 1908, p. 383):

> "These species (with one exception) are all reported by Fontaine from the Shasta flora of the localities along the west side of the Sacramento Valley, and are therefore regarded as of Lower Cretaceous age."

It would appear, therefore, that the near relations of the detached areas of Cretaceous sediment in the Yolla Bolly basin and those of the Sacramento embayment are clearly shown in both their invertebrate faunas and in their floras. However, the character and significance of fossil land plants in marine deposits may well relate more correctly to the physiographic or climatic condition in their source areas than to their position in the stratigraphic column. If these plants have been derived from old and geologically stable land areas, such as that of Klamathonia, many lineages and families may have survived there without interruption from much earlier times than that represented in their burial, and they might also survive many succeeding changes.

With regard to the Cretaceous deposits laid down in the Sacramento embayment and in its delta area, one may expect the earliest sediments would be laid down near their entrance point, or point of exit from the basin. For the most part they would be spread unconformably upon the older terrains existing there. This aspect of the succession has already been discussed elsewhere (Anderson, 1933). As loading of this area progressed it would induce further subsidence, and sediments would spread fan-wise over the floor of the embayment.

Removal of materials from their source region would induce uplift in compensation and would renew the vigor of the streams draining it. In mid-Lower Cretaceous (Horsetown) time such a readjustment is recorded in an uplift already mentioned, which points to an important epoch of the period, at least as affecting California and Oregon, and possibly the entire West Coast, including Alaska.

EMBAYMENT CURRENTS

That currents would be set up within the embayment there can be no doubt. These would arise both from the inflowing water from the Yolla Bolly basin and River, and from the tides entering the embayment from the sea. A complete analysis of these effects cannot be undertaken here. To what degree the sorting action of the currents would be effective upon the sediments is a matter for both deductive reasoning and observation. Currents arising from the inflow from the Yolla Bolly basin would vary with the seasons, and their carrying power would vary with distance from the point of debouchure. Heavy materials would be dropped sooner, and the coarser detritus should be found near its entrance upon the delta. Farther away the materials would be progressively finer, and thus the sediments would vary from conglomerates to sandstones and shales as the drift was followed southward along its course.

The tidal currents entering the embayment at the south would meet the southward-moving currents and partially check them, and at the same time they would themselves be driven eastward against the eastern shore of the embayment, which in effect they would follow northward with gradually diminishing force of current.

Ebb tides would stimulate the currents from the north along the western shore of the embayment and increase their carrying power, whereas marine waters would linger along its eastern margin, where brackish water would scarcely penetrate. Such action would continue throughout Cretaceous time. Each inflowing stream from the west would add its contribution of water and sediment to the general volume of drift. In this way there would be set up a system of circulating currents with a maximum southward flow along the western border and a more gentle northward flow along the eastern side of the embayment. The effect of these currents would be felt not only by the sediments of the embayment but also by the molluscan inhabitants that had entered it with the tides through whatever portal was then open to admit them.

With regard to the detrital sediments, the sorting effects of the currents, and the distribution of the materials, they conform for the most part to deductive principles, with some modification. From the delta head the normal sorting action is recognizable as far south as Thomes Creek, at which point a second, though smaller, stream had entered the embayment from the west. Farther south other streams came in from the same direction, and the sorting action of the currents met interference. Although the positions of various streams active during Cretaceous time can be recognized, many others have been greatly altered by faulting, or piracy, or other causes, and the records are not complete. Nevertheless the principals of sedimentation are not thereby invalidated, and much information can be derived by careful study of the facts.

On the eastern margin of the embayment the sorting effects of currents are not so clear, partly because the deposits are for the most part hidden by later (in part volcanic) terrains. On this side of the embayment the effect of currents is more apparent on the molluscan life of the later Cretaceous epochs, due probably to the absence of freshened water and the more constant presence of marine water which permitted its more abundant development. But, as no early Cretaceous deposits appear on the eastern margin of the embayment, no proof is now available as to the validity of deductive reasoning concerning it.

CRETACEOUS SEDIMENTARY DIVISIONS

GENERAL STATEMENT

The Cretaceous stratigraphic sequence in the Great Valley embayments, on the whole, divide themselves naturally into two great sedimentary series, belonging to earlier and later Cretaceous epochs. The depositional relationship of the two is one of clear unconformity. Wherever their contact has been found, and in fact wherever evidence has been sufficiently sought, the basal beds of the upper series are found to rest discordantly upon those of the lower series. In many places this discordance is marked by beds of conglomerate which carry convincing evidence of disturbance, erosion, and of reworked materials, in part derived from the older series, and in part brought from more distant points, all lodged in the basal beds of the later series. Such facts are seen at many points about the embayments, at the north on the North fork of the Cottonwood Creek, on Roaring River, north of the delta, and on the Cold fork of the Cottonwood, at Elder Creek, and at other points to the south. At other places on the borders of the Sacramento embayment, and on the western border of the Joaquin embayment, conditions of overlap of the later series upon the pre-Cretaceous formations are well known. Such facts are known also far beyond the limits of the Great Valley, in both California and Oregon, and farther north. On the whole the aggregate thickness of the respective series is somewhat equal, although not in any single section. On the western border of the Sacramento Valley (Shasta and Tehama counties), the thickness of the older series far exceeds that of the later, whereas in the Joaquin embayment the reverse is true. These conditions are believed to be for the most part due to a difference in depositional history in the two embayments, although faulting has in some places obscured the essential facts. The respective divisions in the sedimentary succession of the Cretaceous deposits in the Great Valley embayments are shown in Table 1.

SHASTA SERIES

General Statement.—The Shasta series includes that portion of the California Cretaceous succession that was described by Gabb and Whitney

TABLE 1.—*General plan of late Mesozoic succession in California and Oregon*

	Europe	Cottonwood District			Tehama County	Diablo Range	Oregon
Middle and Upper Cretaceous	Senonian *et seq.* Turonian Cenomanian	Chico series			Chico series	Chico series	Chico series
		Hiatus and marked unconformity with local conglomerates					
Lower Cretaceous	Albian	Shasta Series	Horsetown group	Hulen beds	Concretionary sandy shales with rich cephalopod fauna; sandstones	Concretionary shales with few cephalopod species	
	Aptian — Gargasian			Cottonwood beds	Rich cephalopod fauna	Shales with few Ammonoids and Belemnites	Shales with few Ammonoids or other fossils
	Aptian — Bedoulian				Shales with rich cephalopod fauna; *Ancyloceras, Acrioceras, Hoplocrioceras*		
	Barremian					Shales with few Ammonoids or Belemnites *Holcodiscus*	Occasional shales without known fauna
	Hauterivian				Sandstones and conglomerate, with rich cephalopod fauna; Ono zone	Shales with few Ammonoids, many Aucellas and plant remains	
	Valanginian		Paskenta group		Sandy shales including Hamlin-Broad zone *Polyptychites* fauna; *Simbirskites*, etc.	Sandy shales with many Aucellas and cephalopods species	Sandy shales with Aucellas, Ammonites, and Belemnites	Sandy shales with *Lyticoceras, Neocomites*, and *Dichotomites*
	Infra-Valanginian				Sandy shales with *Crioceras, Neocomites Spiticeras*; Duncan Creek zone	Sandy shales with rich Aucella fauna, *Neocomites, Berriasella* and Belemnites		Sandy shales with Aucellas
		Knoxville Series			Upper Jurassic		(Tithonian)

under the name of "Shasta Group." The chronological span of the series is from Neocomian to Gault, inclusive, except such part of the upper Albian as belongs in the Chico series and is unconformable upon the Shasta. On the west border of the Sacramento Valley the Shasta series extends from north to south across the delta area, where it attains a maximum thickness of nearly 27,000 feet, from the axial part of which it diminishes in both directions. Toward the north the thickness drops rapidly to nearly 11,000 feet on Roaring River, to less than 7000 feet on the North fork of Cottonwood Creek, and to 4500 feet on Hulen Creek. The thinning of the sections northward is due in part to transgressive overlap along the north border of the Cretaceous area. Southward from the axial area of the delta the thickness of the series drops to about 25,000 feet at Dry Creek, to 19,500 feet on the Cold fork of Cottonwood Creek, to 16,275 feet on Redbank Creek, and to 13,000 feet on McCarthy Creek. Farther south the thickness of the series is less easily determined, but, notwithstanding the contributions by other streams from the west, the thinning of the sequence continues. At Wilbur Springs, Cache Creek, and in the Berryessa Valley, the thickness is generally less than 14,000 feet, but it is thicker south of Monticello. Farther to the south the series is broken by faulting, and its sections are often incomplete or appear to be missing in large part.

Near Mount Diablo the lowest part of the Shasta series has been recognized by its fauna (ammonoids, belemnoids, and *Aucella*), but the series is much disturbed, and apparently only partial. In some places here it rests unconformably upon Knoxville beds with coarse basal conglomerate, as near Peachtree Springs. The same condition is found in the Berkeley hills and in the Santa Clara Valley, where, west of Redwood City it contains *Aucella*. South of Los Gatos, near Wrights, Cordell Durrell found an example of *Neocraspedites*, well known in the lower Horsetown group of the Cottonwood district, Shasta County.

In the Diablo Range, strata belonging to the Shasta series have been recognized only at intervals, but their presence at such places indicates that they extend along the Range to its southern terminus at Orchard Peak, on the northern border of Kern County, although not now continuously. The lowest beds (Paskenta) have been proved at Mount Diablo, Quinto Creek, Waltham Creek valley, and at Orchard Peak (Devils Den), where they contain diagnostic ammonites and *Aucella*. Most of the published references to "Knoxville" beds in the Diablo Range refer instead to lower Shasta (Paskenta) beds.

In the vicinity of Corral Hollow, and on Hospital Creek, farther south, the upper part of the series has been proved by characteristic ammonites (*Cleoniceras* and *Puzosia*).

Relations of the Shasta Series.—As found in its more complete sections

the Shasta series is set off from the underlying Knoxville and the overlying Chico series by quite well marked unconformities. As has already been shown (Anderson, 1933), its basal beds rest in some places discordantly upon Knoxville beds, with thick basal conglomerates which contain distinct evidences of diastrophism, erosion, and transported material, some of which is fossiliferous, derived from underlying Knoxville and older formations. In other places the basal beds rest directly upon pre-Knoxville (Franciscan, or older) rocks, as in the Yolla Bolly basin, Morgan Valley, Russian River Valley, Mount Diablo, and the Diablo Range. In a few exceptional places, as in the McCarthy Creek-Elder Creek district, this unconformity is less evident, and the succession from upper Knoxville to lower Cretaceous has been believed to be continuous. Similar conditions are rarely found farther south, but for the most part unconformity is readily proved. In many places the unconformity of the two series is marked by bodies of conglomerate at the base of the Shasta series, resting directly upon dark clay shales of the Knoxville series. In some places they contain Upper Jurassic (Tithonian) fossils. These conditions of unconformity have been found by N. L. Taliaferro[3] in southwest Fresno County and in southern San Luis Obispo County, and are known to extend as far south as the Santa Ynez River, Santa Barbara County.

The Shasta series is overlaid at the top by sediments of the Chico series, having in many places distinctly basal, or near-basal, conglomerates which contain evidences of unconformity. This unconformity was recognized by both White and Becker and has been observed in later field work by others, including Taff (1935) and the writer. The geographical extent of this unconformity is not yet known, although it has been found at many places in northern California and in southwestern Oregon (Cottonwood Creek, Cold fork, Elder Creek, Hornbrook, Jacksonville, and Riddle), and, according to Martin (1926, p. 477–478), it seems to have been recognized in Alaska (Yukon and Kuskokwim Valleys, Chitina Valley), although the definite horizon of the overlaps are not always indicated.

The faunal changes in passing from upper Knoxville to Lower Cretaceous beds are striking. The Tithonian aspect of the former is seen in the occurrence of many species of *Cylindroteuthis*, berriasellids of the group of *B. calisto* (d'Orbigny), *Phylloceras*, of the lineage of *P. consanguineum*, and many characteristic forms of *Aucella*, of the types found in the upper Jurassic of Russia. In the Lower Cretaceous this assemblage is replaced by a distinctly different fauna, including other species of *Berriasella*, *Neocomites*, *Lytoceras* (group of *L. saturnale* nov.), *Acroteuthis*, and *Aucellae* (group of *A. crassicollis*, *A. inflata*, and *A. lahuseni*), and by various forms of pelecypods and other classes of Mollusca.

As originally defined by Whitney (1869), the "Shasta Group" (series)

[3] Unpublished notes and fossil collections.

includes all of the Lower Cretaceous sequence ("Neocomian to Gault inclusive") found in the Great Valley, but it should terminate at the basal beds of the Chico series, the earliest of the California Upper Cretaceous. As far as detailed exploration has extended in California and in Oregon, these relations have been found at both the bottom and top of the Shasta series. They have been found at its base near Mount Diablo by Taff, and in the Berkeley Hills by L. W. Henry and the writer, and in the Santa Clara Valley and farther south. In southern Oregon (Douglas and Curry counties), Lower Cretaceous deposits contemporaneous with the Shasta series are well known in which similar basal conglomerates have been described by Diller (1898, 1924) and have been observed by the writer. In some localities they rest upon beds that may belong to the Knoxville series, and in other places upon older formations. The basal relations here are similar to those in California; namely, those of unconformity. In this region the stratigraphic relations at the top of the Shasta series are not fully known, although they are perhaps the same as in California. About the Rogue River Valley, and near Riddle, Oregon, lower beds of the Chico series rest directly upon pre-Cretaceous formations and thus show conditions of a wide overlap in late Albian and Cenomanian times.

Stratigraphic Groups.—The Shasta series in the Great Valley sections in California has been divided into two major groups, primarily upon paleontological grounds, but the division is supported by other important criteria, found in their distribution and lack of coincidence, and in the thick beds of conglomerate usually lying between them, and in some places by direct evidence of disconformity and transgression.

The later, and somewhat thicker, portion of the series constitutes the Horsetown group. As originally defined by White (1885), this term seems to have covered the whole of the Lower Cretaceous, and thus became synonymous with the Shasta "group" of Whitney. It is in accord with stratigraphical facts to restrict the name Horsetown, as was done by Stanton and Diller (1894) and to include the lower portion of the series in a unit, for which the name Paskenta group is appropriate. These terms are applicable not only in the district about Paskenta, Tehama County, but in the Cottonwood district, Shasta County, and throughout California and southwestern Oregon. As interpreted by Stanton, the base of the Horsetown group occurs immediately at Ono, Shasta County, and is recognizable in Tehama County. This division is supported by both stratigraphic and faunal criteria.

PASKENTA GROUP

General Statement.—The name Paskenta was suggested by the writer long ago (Anderson, 1902a, p. 43–45) for the lower part of the Shasta series, as since defined, in the belief then prevalent that it formed a repre-

sentative part of the Knoxville series. Later investigation has shown this to be an error; the Knoxville series is distinctly Jurassic, whereas the Paskenta group has a chronological range strictly within the Cretaceous system—Berriasian-Valanginian—and is quite distinct from the Knoxville series.

Type District.—In its type district (Elder Creek to Thomes Creek and southward), the lithological composition of the Paskenta group begins at the south with massive lenses of conglomerate, above which it is prevailingly sandy, with alternating beds of sandstone and sandy shales. South of the delta area its fauna is largely Aucellan, containing many forms of rugose, heavy-shelled types not found in the Knoxville series. With these are found various species of cephalopods that show its chronological position to be below the Hauterivian stage, including species of *Berriasella* and *Neocomites*. Some of these species are new, others have been described by Stanton (1895, p. 80–82) and others. In the Cottonwood district few, if any, *Aucellae* occur in this group, although some of its cephalopods and other types of its pelecypods do occur there.

The Paskenta group has, therefore, been identified stratigraphically and faunally on both sides of the delta area—that is, in its type area and in the Cottonwood district, although there are definite faunal differences. In the delta area also it has been identified directly by a small molluscan fauna, including *Neocomites*, and indirectly by its stratigraphic relations with the Horsetown group above and by the absence of Knoxville beds beneath it. Its strata can also be traced across the delta area. The Paskenta group, like the Horsetown, is thickest in the axial areas of the delta and thins from there toward the north and toward the south.

In the axial area of the delta the group has a thickness of 11,000 feet; northward, on the Middle fork of the Cottonwood, its thickness is 8000 feet; on Roaring River, its thickness is about 4000 feet. Toward the south the thinning is more gradual. But in all sections of the series traversed the thickness of the Paskenta is less than that of the Horsetown group, and from this fact it may be supposed that the time interval of its deposition was shorter and in the same proportion.

In most sections of the Shasta series the line of division between these groups has been determined faunally, although in some places the separation is aided by lithological changes, and the line is marked by lenses of conglomerate at the base of the Horsetown group. In the Cottonwood district such conglomerates in the lower part of the Horsetown group rest directly upon fine shales in the upper part of the Paskenta group. These conglomerate beds begin at the north near Ono, in a single bed about 60 feet in thickness, but farther south other similar beds appear above and beneath, until on Roaring River as many as four such beds enter the section in a stratigraphic thickness of 1000 feet. Farther south these

beds diminish in volume or are lost in the axial areas of the delta. Toward the south, on the Cold fork of the Cottonwood, are thick beds of conglomerate which seem to represent the lower part of the Horsetown group, as evidenced by fossils found nearby. About 4500 feet lower in the section the basal beds of the Paskenta group (and Shasta series) is marked by a heavy bed of conglomerate (near the Stephenson place, now abandoned) containing many broken and beach worn shells, some of which have been described by Stanton (1895, p. 14, et seq.).

Between Elder Creek and Thomes Creek the line of division is not marked by conglomerates, and the basis of separation is almost wholly paleontological, although there are lithological differences. The Paskenta group here contains a greater percentage of sandy sediment than the Horsetown, which is composed largely of shales. The same lithological differences are conspicuous in the Shasta series southward as far as Berryessa Valley, Napa County, and farther. In some places the lower part of the Paskenta group contains limestones, as near Wilbur Springs, Morgan Valley, Pope Valley, and near Monticello. Such limestones have also been described near Dillard, Douglas County, Oregon, and in some of the Alaskan sections ("Nelchina limestone") (Martin, 1926, p. 313–315).

For the most part these limestones have their own facies of molluscan fossils, but in all cases they show a low position in the Cretaceous sequence, as is indicated in the descriptions of many of them given by Stanton.

The relative stratigraphic thickness of the Paskenta and Horsetown groups approximates generally that in the McCarthy Creek section, in which they are represented by the following figures:

	Feet
Horsetown group	7,660
Paskenta group	5,340
Total thickness	13,000

Faunal Zones.—In both the Paskenta and Horsetown groups various faunal zones have been found which are recognizable as such in the several districts where work has been done north of the Berryessa Valley. Many of these zones are rich in fossils and can be traced for considerable distances along their strikes. As most of the larger streams on the west border of the Sacramento Valley cross the Cretaceous zones nearly at right angles to the strike and give good exposures of the beds, these fossil zones may be recognized in the successive streams, and the sequence of these zones can be determined. In this way the faunas of the several zones become enriched by additions obtained from the successive streams.

In addition to the fossil zones that are recognizable there are some interspersed fossil localities whose stratigraphic positions have been determined by traverses. In the Paskenta group these zones are more general,

or broader, and have yielded a less satisfactory sequence of faunas in any single section, although a general order is easily seen. In this group the contrasts of faunas found in corresponding beds north and south of the delta axis are at first sight somewhat surprising but, as will be shown later, are explainable upon the basis of ecological conditions in the various districts and the different faunal facies which have been developed. In the districts in which the faunas of the Horsetown group are more complete the successive zones are more numerous, more continuous, and more representative, than in the older group. For these reasons the Horsetown group offers better opportunity for faunal zoning, especially in the district north of the delta areas.

There are few lithological units of small thickness in either group that seem to have continuity or utility as smaller subdivisions, except in limited districts, and these have not greatly affected the faunal sequence. The broader lithological zones already described seem to have had some selective influence upon the enclosed invertebrate assemblages, due no doubt to conditions of deposition and to their food supplies and other factors.

The following stratigraphic column is representative of the Lower Cretaceous groups occurring in the Cottonwood district of the Sacramento embayment and of the sequence of characteristic faunal assemblages. In the districts south of the delta areas the faunal order appears to be the same, but the faunas are dominated by other types, notably *Aucellae*, which, in the lower group, occur in vast numbers. The order in which some of the cephalopods occur does not wholly accord with that of England, or of other countries. Only a distortion of the facts could render their agreement more perfect.

FAUNAS OF THE PASKENTA GROUP

General Statement.—The type district of the Paskenta group is immediately about the village of this name in western Tehama County, extending northward beyond Elder Creek, and southward toward Newville. In this area the group has a thickness of 5300 to 5500 feet, the strata of which have already been partly described. In this district the lower half of the group is made up of conglomerates, followed by thin-bedded sandstones and sandy shales, whereas the upper portion is shaly, with few beds of sandstone. The lower portion of the group contrasts lithologically with the underlying Knoxville shales and also with the shaly upper part of the group itself.

It is not believed that these lithological features maintain in all its sections, although as far as known the Paskenta group is prevailingly sandy near its base, and frequently contains thick beds of basal, or near-basal, conglomerates. The fauna of the lower sandy beds is characterized

here by a considerable variety of *Aucella*, including the rugose, heavy-shelled forms given in the list below. In this part of the group belongs the so-called "*Aucella crassicollis* zone," although this species itself seems to be somewhat rare. This list, although probably not complete, is representative of these beds, here at least, and should serve for their identification in other parts of the State, or of the West Coast. The cephalopod species found here include:

Neocomites stippi nov.
Dichotomites tehamaensis nov.
"*Desmoceras*" *californicum* Stanton
"*Hoplites*" *crassiplicatus* Stanton
"*H.*" *angulatus* Stanton
Berriasella sp. indet.
Subastieria sp. indet.
Lytoceras saturnale nov.
Bochianites paskentaensis nov.
Acroteuthis shastensis nov.
A. onoensis nov.
A. wilcoxi nov.
A. macarthyensis nov.
"*Simbirskites*" *mutabilis* Stanton

Among the pelecypods should be included:

Inoceramus ovatus Stanton
Aucella lahuseni Pavlow
A. piriformis Lahusen
A. solida Lahusen
A. terebratuloides Lahusen
A. keyserlingi Lahusen
A. inflata Toula
A. uncitoides Pavlow
A. crassicollis Keyserling
A. crassa Pavlow
A. nuciformis Pavlow

Bochianites paskentaensis has been found at both the bottom and top of these sandstones near McCarthy Creek, associated with species of *Aucella*.

The Valanginian aspect of the fauna given in the above list seems unquestionable. Most of the aucellan species have been recognized by Pavlow as occurring in the Lower Cretaceous of Russia (zone of *Polyptychites polyptychus*, or of *Subcraspedites stenomphalus*). In Russia some of these species seem to range downward into Tithonian horizons (zone of *Berriasella rjasensis*). "*Hoplites*" *crassiplicatus* Stanton appears to be a berriasellid of a lower Volgian type, related to "*Hoplites*" *rjasensis* Lahusen, as figured by Nikitin (Stanton, 1895, p. 81). The beds containing *Bochianites paskentaensis* and "*Simbirskites mutabilis*" Stanton, associated with species of *Aucella*, have been referred by Spath (1924) to the top of the Infra-Valanginian—that is, to the zone of *Subcraspedites stenomphalus* Pavlow.

All the aucellan species listed above, and three or more species of *Dichotomites* occur with *Bochianites paskentaensis* and are overlaid by beds containing *Lytoceras saturnale* and *Acroteuthis wilcoxi*, and species of cycads. On the Wilcox ranch this zone is stratigraphically narrow and lies about 1800 feet above the base of the Paskenta group. On McCarthy Creek, near the base of the group, were found *Lytoceras saturnale*, *Phylloceras* sp. *Aucella uncitoides*, *A. inflata*, *A. lahuseni* Pavlow, and other unidentified species. Not far below the base of the Paskenta group in this district is the plant horizon from which Diller (1908, p. 385) has given

a considerable list of plants, nine of which were specifically named, with three others named only generically. These plants were determined by Knowlton, whose assignment could be interpreted to mean the uppermost beds of the Knoxville series, as here understood. The horizon is that of "Zone K," of an earlier contribution (Anderson, 1933, p. 1252). The foregoing list contains the most characteristic molluscan species found here in the lower part of the group. The upper portion of the group in this district is composed almost wholly of slightly indurated clay shales, in which there are occasional lenticular, but thin beds of limestone, and more rarely thin beds of sandstones. In the lower part of these shales on McCarthy Creek, not far east of the Burt ranch house, are found *Neocomites jenkinsi* nov., *Thurmannia paskentae* nov., *Subastieria* sp., *Aucella nuciformis* Pavlow, *A. terebratuloides* Lahusen, and various plant remains. About 1200 feet higher in the section on McCarthy Creek were obtained a fragment of *Lytoceras saturnale* and *Aucella piriformis*, and with them a large leaf of a cycad species and other plant remains. In the dark shales not far above this horizon were found a small species of *Lytoceras* cf. *L. traski* nov. and a small species of *Aucella*. Farther south the upper shales of this group have not yielded determinable fossils. Such shales appear in the same stratigraphic position in the section as far south as the Berryessa Valley, but no fossils have been found in them. In lithological character these shales do not differ from those of the Horsetown group nor from shales in the Knoxville series, as found farther west.

The line of division between the Paskenta group and the overlying Horsetown beds in this district is not marked by any lithological change, and its position is often a matter of approximation or of doubt.

Cottonwood District.—In the northern part of the Cottonwood district—that is, in the triangular area north of the Middle fork and west of Ono—there is a thick sequence of sandstones, sandy shales, and clear dusky shales, and at their base some bouldery conglomerates. The entire sequence lies below the fossil-bearing beds at Ono and beneath the conglomerates here regarded as forming the basal beds of the Horsetown group. Stratigraphically these shales and sandstones occupy the position of the Paskenta group as found in its type district. Westward from Ono this group becomes progressively thicker by the successive emergence of lower beds along its contact with the basement rocks. North of Roaring River the group varies in thickness from less than 1000 feet near Ono to nearly 4000 feet on the upper Roaring River. The Lower Cretaceous age of these beds is unquestionable, and, although faunally unlike those of the Paskenta group on McCarthy Creek, and northward, lacking its Aucellan fauna, it must be regarded as forming a facies of this group and as being of contemporary deposition. In its lithological order there is much similarity in the two districts, in that the lower half of the group is prevailingly

sandy, and the upper part composed of shales. Although not many molluscan species have been found here which characterize the Paskenta group in its type district, several forms of equally diagnostic value have been obtained, showing that the lower beds in this area come within the limits of the Valanginian stage, and, therefore, within the limits of the Paskenta group.

Thus far no species of *Aucella*, *Berriasella*, or *Bochianites* has been found in this group north of the axial parts of the delta, and this fact is noteworthy as showing the contrast in the faunas of the two areas. The species common to the two areas include *Lytoceras saturnale*, *Acroteuthis shastensis*, *Acroteuthis onoensis*, *Inoceramus ovatus*, and *Crioceras latum* Gabb. In addition to these a few genera may be mentioned, which, although not specifically identical with those south of the delta, still have diagnostic value. These include *Thurmannia*, *Neocomites*, *Subastieria*, and olcostephanids. In both districts *Lytoceras saturnale* ranges throughout most of the group. In the Cottonwood district the upper shales of the Paskenta group include the Hamlin-Broad zone represented at Locality 113 (Calif. Acad. Sci.), 4 miles southwest of Ono, from which have been obtained:

Polyptychites lecontei nov.
Polyptychites hesperius nov.
Aspinoceras hamlini nov.
Acroteuthis shastensis nov.
Simbirskites broadi nov.
Lytoceras saturnale nov.
L. aurarium nov.
Ostrea indigena nov.

In the same zone, not far distant, were found *Thurmannia jupiter* nov., *Acroteuthis onoensis* nov., and *Crioceras latum* Gabb.

The Hamlin-Broad zone lies about 450 feet below the lowest bed of conglomerate at the base of the Horsetown group. At Locality 113 (Calif. Acad. Sci.) it is more than 1000 feet above the base of the section. Farther west the zone rises above the basal contact, due to the emergence of older beds beneath it. From the lowest bed exposed on Duncan Creek, west of Ono, were obtained *Spiticeras duncanense* nov., *Neocomites russelli* nov., *Crioceras latum* Gabb, and *Hoplocrioceras* sp.

The stratigraphical relation of the Hamlin-Broad zone to the basal beds of the Horsetown group shows its position in the chronological column to be below the Hauterivian, and therefore within the Valanginian. The occurrence in it of two species of *Polyptychites*, one of which is near *P. polyptychus* Keyserling, a species of *Simbirskites* near *S. decheni* Pavlow, a species of *Thurmannia*, of the group of *T. boissieri* (Pictet), indicates a low position in the Valanginian sequence. When the zone is followed eastward it passes into the almost barren sandstones and conglomerates at the base of the section north of Ono. In the opposite direction it rises to 1200 feet above the base within a mile of Locality 113 (Calif. Acad. Sci.), and a few miles farther west it is nearly 3000 feet above the basal bed of the group. Near the bridge on the Menzell ranch three

examples of *Lytoceras saturnale* were obtained from beds near the base of the group. Two and a half miles farther west, at Locality 1665 (Calif. Acad. Sci.) on Duncan Creek, still lower beds are exposed, although the lowest beds are here faulted down and hidden. From the somewhat brecciated strata, and from blocks possibly brought up from beds now concealed, were obtained *Spiticeras duncanense* nov., *Neocomites russelli* nov., *Crioceras latum* Gabb, *Crioceras* cf. *nolani* Kilian, and *Hoplocrioceras remondi* (Gabb). These species may not all represent the same horizon, but they show a low position in the Valanginian sequence, and therefore are low in the Paskenta group, although not from its lowest beds found in the Cottonwood district, or in the district north of Thomes Creek.

On the J. Sylvester ranch, 2 miles south of Locality 1665, from beds 1000 feet higher in the section, were obtained *Inoceramus ovatus* Stanton and *Hoplocrioceras remondi* (Gabb). The first of these, described from a low part of the group near Elder Creek, occurs here also in nearly the same stratigraphic level. The second species has also been found near the Watson school on Roaring River nearly 1000 feet above the base of the section.

In the western part of the Cottonwood district basal and near-basal conglomerates occur at many places, as at Beegum Peak, and 2 miles to the north. Some of these basal and near-basal conglomerates in the Cottonwood district seem to mark the debouchure of streams entering the embayment from the hinterland during early Cretaceous time. One such stream, still carrying water, is at the big bend of the North fork of Cottonwood Creek, where two branches of the stream emerge from the crystalline rocks of the basement complex. The basal conglomerates at this point are 40 to 100 feet thick. Some of the boulders have a diameter of 2 or 3 feet and consist of various types of rock.

A locality still farther west, at the base of the section, is near the old well-known "Arbuckle Diggings," frequently noted by Gabb. From this locality, Gabb listed a number of invertebrate species which he believed had been found there. The position of the old mine is 12 miles west of Ono, at the base of the series. Shales and thin-bedded sandstones formed the "bed-rock" of the old diggings. Repeated search here during the last few years has failed to discover any trace of molluscan fossils within a radius of a mile about the old mine. The species listed by Gabb include some that could not have come from this locality, and it is very doubtful if any of them were taken from the mine itself. The list given by Gabb (1864) follows:

"Crioceras" percostatum Gabb
"Ancyloceras" sp. undet.
Baculites chicoensis Trask
Ammonites traski Gabb
A. batesi Trask

The species contained in this list represent three or more widely separated horizons in the Cottonwood district. *Baculites chicoensis* belongs in the

Chico series and has not been found lower in the succession. *Tropaeum percostatum* (Gabb) represents a lower Gargasian horizon (middle Horsetown). *Polyptychites traski* belongs in the Hamlin-Broad zone, not found at Arbuckle Diggings. There is little evidence that any of the species of this list were ever found at this locality. Its stratigraphical position is below that of Locality 1665 at Duncan Creek, and it should be older, and therefore belongs in the Paskenta group. The beds exposed here can be traced south toward Beegum Creek and are among the oldest beds outcropping north of the delta.

Identity of the Group.—On account of the faunal contrasts in the Paskenta group north and south of the delta axis, some additional facts concerning the essential identity of the strata are here offered. Both areas lie upon the same side of the embayment within a geographical distance of 25 miles, and with an intervening distance of less than 20 miles. There is little difference in the two districts as to their environs, past or present. In each, the sequence of faunas is nearly complete from early Valanginian to middle Albian; each area includes, therefore, the entire sequence of the Shasta series. The relation of the Paskenta group to the underlying formations in the two districts differs only in the fact that north of the delta it rests directly upon pre-Mesozoic crystalline rocks, whereas at the south its lower beds rest in some places with seeming conformity upon the Knoxville series. From these general facts it could be assumed that the strata below the Horsetown group in the two areas must be contemporary, and no other alternative seems to be open. However, in addition to these facts, there are various diagnostic molluscan species common to both areas, and, insofar as they occur, the faunal order is the same in both. Other criteria have already been given in support of this view, which need not be repeated here, for the reason that all other evidence seems unimportant in view of the fact that the beds can easily be followed along their strike from one district to the other across the intervening delta area, and, therefore, their identity is hardly subject to doubt, whatever faunal differences may be found.

DISTRIBUTION OF THE PASKENTA GROUP

General Statement.—The areal and geographical distribution of the Paskenta group in California and Oregon far exceeds that of the Horsetown group, since it occurs in many places in the Coast Ranges in both States where no evidence of the latter group has been reported. Judging from published reports this condition appears to extend to northern Washington, to the mainland of British Columbia, and also to Alaska. In most places along the Pacific Coast in which Lower Cretaceous deposits have been recognized by their faunas, it is the lower, rather than the upper, group that has been proved.

Yolla Bolly Basin.—Only beds of the Paskenta group have been identi-

fied in the deposits of the Yolla Bolly basin (Big Bar, Rattlesnake Creek, and Redding Creek) in Trinity County. Most of these places were visited by Diller (Diller, 1908, p. 379–384), whose accounts contain fossil determinations by both Stanton and Knowlton, since both molluscan fossils and plant remains have been collected there. Concerning the molluscan fossils from Big Bar, Stanton reached the conclusion that the horizon was within the "upper Knoxville," which in this paper is that of the Paskenta group. The deposits at Redding Creek were regarded by Stanton as being somewhat higher, possibly within the lower Horsetown group. However, in addition to the molluscan species mentioned by Diller, others have since been obtained here by N. E. A. Hinds and by G. D. Hanna and the writer. Without giving complete lists here, they include the following:

Pecten californicus Gabb
Terebratella californica Stanton
Phylloceras trinitense nov.
Hoplocrioceras yollabollium nov.

The first two species of this list have been found at Stephenson's on the Cold fork of Cottonwood Creek, in beds of Paskenta age, and the third has been found in similar beds at Riddle, Oregon. The holotype of *Crioceras latum* Gabb probably came from this area, whence it had been carried to its point of discovery on the Trinity River. Some of the species found here have also been found at Locality 1665 (Calif. Acad. Sci.) on Duncan Creek, in beds low in the Paskenta group.

From Rattlesnake Creek, Diller lists (1908, p. 382) only plants, although he also mentions molluscan fossils. The plants were regarded by Knowlton as Jurassic. More recently, Parker D. Trask and the writer obtained here various molluscan fossils, including the following genera: *Cyrena*, *Corbula*, *Astarte*, *Goniomya*, and *Unio*, all the species of which are new and partly described here for the first time.

The locality at Big Bar on the Trinity River has yielded both plants and Mollusca, all of which are listed by Diller (1908, p. 380–381). From the twelve or more species of plants, Knowlton reached the conclusion that the horizon was that of the "Jurassic of Oregon," which for the most part is referable to the Paskenta group. The molluscan forms obtained here by Diller included *Aucella crassicollis* Keyserling, *Pecten*, *Mytilus*, *Cyprina*, and *Unio*, from which Stanton concluded (Diller 1908, p. 381) that they were "upper Knoxville," and, as already shown, this is correlative with the Paskenta group, as are all the Cretaceous beds found in the drainage of the Trinity River system.

Concerning the several residual deposits found in this basin Diller says (1908, p. 402):

"The strata containing the Jurassic flora of the Klamath Mountains are conspicuously unconformable to the underlying Paleozoic rocks and contain not only a marine, but also a fresh water fauna. They were deposited by the sea advancing over the slopes of the subsiding Klamath Mountains."

That the sea advanced into this basin from the Sacramento embayment can hardly be doubted, since both faunas and floras were compared with, and correspond to, those of the Paskenta group in its type district in the Sacramento Valley.

Wilbur Springs.—South of its type district the Paskenta group is continuous along the west border of the Great Valley, and its lower beds at least are highly fossiliferous in many places (Newville, Winslow, Government dam, near Elk Creek, and near Wilbur Springs). Most of the fossils found in these beds are species of *Aucella*, of the robust, heavy-shelled types (*A. inflata*, *A. crassa*, and *A. uncitoides*), and a species of *Acroteuthis*. The unconformable relation of these beds to the underlying Knoxville shales is well shown at Newville, at the Winslow bridge, at the Government dam, and also at Wilbur Springs.

The district about Wilbur Springs is typical and of more than ordinary interest, partly for having had frequent mention by earlier writers. One and a half miles northeast of the Hotel, near Bear Creek, the lower thin-bedded sandstones of the Paskenta group contain *Aucella crassa*, *A. inflata*, *A. uncitoides*, and *Acroteuthis* sp. At this point these beds rest in part upon Knoxville strata and in part upon older rocks. Two miles southwest of the Hotel the same beds rest upon Franciscan cherts or upon associated serpentine, but they contain these same fossils. Between these localities are the "white limestones," often mentioned as containing *Rhynchonella whitneyi*, *Pecten complexicosta*, and *Modiola major*, resting directly upon serpentine and Franciscan rocks. Along Bear Creek the Knoxville beds are exposed beneath those of the Paskenta. From the former Stanton (1895, p. 19, 20) has reported *Aucella piochi* Gabb, *Phylloceras knoxvillense*?, and *Belemnites* sp. All these species have since been obtained here, although the belemnite appears to be a form of *Belemnopsis*, not uncommon in the Knoxville beds.

The conglomerates mentioned by Stanton (1895, p. 19) are at the base of the Paskenta group, south of the Hotel, and of the Gibson mine, and also east of Bear Creek.

It is important to note here the overlap of the Paskenta beds across the narrow zone of the Knoxville and their contact with various types of older rocks.

Morgan Valley, Lake County.—This district was visited by Whitney, Stanton, and later by the writer. The beds exposed here are chiefly sandy shales, but they also include clay shales, limestones, sandstones, and pebbly conglomerates. The pebbly conglomerates constitute the basal beds of the Paskenta group that appear to rest directly upon formations referable to the Franciscan series, including cherts, and other types, all much disturbed by serpentine intrusions. There are also exposures of Knoxville beds in parts of the district, but they cannot be described here.

From the sandy shales overlying the Franciscan rocks were obtained *Aucella crassa*, *A. inflata*, and from the limestones, other species. Stanton (1895, p. 19, 20) reports from this district *Aucella crassicollis*, *Pecten complexicosta*, *Modiolus major*, *Astarte trapezoidalis*, *Turbo morganensis*, *Atresius liratus*, and various other species, all of which are of Paskenta age. White (1885) had reported other forms from this district, some of them of Horsetown age, but their occurrence in Morgan Valley needs confirmation. In this district the relations of the Paskenta beds to the older rocks are the same as at Wilbur Springs, that is, one of unconformity. The limestones here are similar to the "white limestones" of the latter district.

Berryessa Valley, Napa County.—Strata of the Paskenta group are well represented along the western border of the Berryessa Valley, west of Monticello. At the base they include pebbly conglomerates and sandstones, and higher in the section are scattered lenses of limestone. The latter occur at many points on the small hills a few miles west of Monticello. From the lower beds of this group west of Monticello, Eldridge Drew obtained *Aucella piriformis*, *A. keyserlingi*, *Belemnites* sp., *Inoceramus ovatus* Stanton, and from the limestone lenses higher in the section, *Modiolus major*, *M. stantoni* nov., *M.* (*Volsella*) *onoensis* nov., *Turbo? humerosus* Stanton, and *Atresius* sp.

Pope Valley.—West of the Berryessa Valley the sandy beds of the Paskenta group form the floor of the smaller Pope Valley. The sandy shales and sandstones with lenses of limestone rest unconformably upon Franciscan strata, or upon intrusive rocks by which the latter have been cut. From the sandy shales of the Paskenta group on the south border of the valley the writer collected *Aucella piriformis*, *A. uncitoides*, *A. crassa*, and fragments of belemnites. The overlap of the Paskenta beds upon pre-Knoxville formations is well illustrated in this valley, and upon both north and south borders of it.

Napa Junction.—From the old "cement-rock" quarry, 4 miles north of Vallejo, where the basal beds of the Paskenta group are exposed, the writer obtained a small collection of fossils, including *Modiolus onoensis*, *Lima multilineata* Stanton, *Inoceramus vallejoensis* nov., and numerous borings of pholads. The beds here include calcareous shales, pebbly sandstones, and limestones. They rest unconformably upon Franciscan rocks.

Mount Diablo District.—The lower beds of the Paskenta group are well exposed about Mount Diablo, cropping out on both its east and west flanks. On the east flank near Olafsen's house and west of Curry Canyon, the writer obtained an example of *Lytoceras* cf. *saturnale* nov., and near the quicksilver mine, northeast of North Peak, well preserved examples of *Aucella inflata* have been collected and are in the possession of the University of California. On the northwest flank of the mountain, west

of Peachtree Springs, a basal conglomerate of the Paskenta group forms a conspicuous outcrop. From boulders embedded in this conglomerate, Taff, Hanna, and Cross collected *Aucella piochi* and other related species, and from the matrix they obtained examples of *Acroteuthis* cf. *onoensis* nov., a form characteristic of the Paskenta. From overlying shales nearby they collected numerous fragments of *Acroteuthis impressa* (Gabb), and well-preserved specimens of *Aucella inflata*, *A. piriformis*, and various small gastropods. This exposure is probably that from which Turner (1891) obtained specimens of *Belemnites*.

Berkeley Hills.—A complete account of the Lower Cretaceous sequence in the Berkeley Hills cannot be given here, since these beds have not yet been segregated from the underlying Knoxville, both of which occur here, and in unconformable relation. Only the lower beds of the Paskenta group have been identified by fossils, but they are much disturbed and broken by faulting. From the western flank of the hills in the northern part of Berkeley, Lawson (1914) has reported a number of Paskenta species occurring in limestone, including *Modiolus major*, *Lucina colusaensis*, *Pecten complexicosta*, *Myoconcha* sp., *Turbo* sp., *Atresius liratus*, and "*Hoplites*" sp. All these forms are characteristic of the lower beds of the Paskenta group, as found farther north. In the vicinity, and also from the basal beds of the group, Leonard Henry obtained *Mytilus arlingtoni*, *Aucella crassicollis*, *A. inflata*, *Belemnites* sp., *Balanus berkeleyensis* nov., and *Balanus* sp. These fossils were obtained from a pebbly sandstone overlying Knoxville shales. From a calcareous boulder embedded in the pebbly matrix, Henry obtained examples of *Aucella piochi*. All these fossils are in the Museum of Paleontology, University of California.

That the pebbly sandstone represents a near-beach deposit is evidenced by the presence in it of species of *Mytilus*, *Balanus* and many broken shells of other species. The beds here described resemble those found at Napa Junction, 4 miles north of Vallejo.

Knoxville beds consisting for the most part of dark clay shales, often fossiliferous, have been identified at other points along the west flank of these hills farther south. They are usually involved with masses of serpentine, or overlie Franciscan cherts, and are greatly faulted. On the south border of the Concord quadrangle, 1¼ miles northwest of Lake Chabot, C. Durrell discovered an invertebrate fauna containing *Aucella hyatti* Pavlow, *Terebratella* cf. *californica*, *Ophioglypha* ? (brittle star), and *Pentacrinus* sp. From similar dark shales about 1500 feet higher in the section, R. L. Rist and the writer obtained species of *Perisphinctes*.

Santa Clara Valley.—As in most other areas in the Coast Ranges in which beds of the Paskenta group occur in association with Knoxville strata, no attempt has been made to distinguish these formations in the Santa Clara Valley, in which both occur. R. Crandall (1907) has sup-

plied helpful data bearing upon this problem in the environs of this valley. Many of the exposures described by him are referable to the Paskenta group, and others to the Knoxville series. In all instances in which *Aucella crassicollis* and associated forms have been listed, the strata should be regarded as belonging to the Paskenta group.

A locality described by Branner, Newsom, and Arnold (1909) as 3 miles west of Redwood has yielded *Aucella crassicollis* and *Amberlya dilleri*, both belonging in the lower beds of the Paskenta group. Smith has recorded the finding of "*Hoplites*" a few miles to the north of this locality. All these forms are referable to the Paskenta group. More recently O. P. Jenkins and E. W. Galliher[3] have discovered fragments of a crioceratid shell in the dark shales at Point San Pedro, which seems to fix the age of these beds as lower Horsetown.

In 1908 Josiah Owen discovered a large specmen of *Inoceramus* near *I. vallejoensis* nov., in dark shales near Alma, south of Los Gatos, which indicates the Paskenta group.

Diablo Range.—Some evidence has recently been discovered proving the occurrence of Lower Cretaceous strata in various parts of this range, the accounts of which have not yet been published, but they show the presence there of both Paskenta and Horsetown beds. Pack and English (1914) report the finding of *Aucella crassicollis* in Lower Cretaceous strata in the Waltham Creek Valley, southwest of Coalinga. During field work in 1937 N. L. Taliaferro discovered Knoxville beds with *Aucella hyatti* and fragments of Perisphinctid shells in the Waltham Creek Valley, not far from the Fresno Hot Springs.

These beds were overlaid unconformably by basal Paskenta conglomerate, containing *Neocomites neocomiensis* (d'Orbigny) and *Acroteuthis macarthyensis* nov. Near Orchard Peak (Devils Den district), G. D. Hanna and C. C. Church obtained many fossils from calcareous gray shales in the lower part of a thick sequence of beds dipping toward the northeast. These fossils include *Aucella crassa*, *A. crassicollis*, *A. inflata*, *Acroteuthis impressa*, *A. kernensis*, and *Lytoceras* cf. *saturnale*. These species were found in near-basal beds, which here rest upon Franciscan rocks and serpentine, with no Knoxville beds intervening. It could be inferred from the facts thus far recorded that only the lower part of the Shasta series (Paskenta) occurs in the Diablo Range, but in addition to the above records it may be stated that both lower and upper Horsetown fossils have been found on the eastern flank of the range, especially north of the Panoche Hills. These include species of *Neocraspedites*, *Hemibaculites*, *Sonneratia*, and *Beudanticeras*. Near Quinto Creek, southern Stanislaus County, Paskenta beds with *Aucella crassa*, *A. crassicollis*, and belemnites, occur, overlying Knoxville beds containing *Aucella stantoni*, *A. krotovi*, and a small species of *Oppelia* (*Streblites*).

[3] All citations without references are from unpublished notes.

From these records it appears that both Knoxville and lower Shasta strata occur at intervals in the Diablo Range, chiefly on its eastern flank, and that as far as is now known the two series are unconformably related.

Santa Lucia Range.—Sandstones and shales form a thick sequence of strata along both flanks of the Santa Lucia Range and extend from Pine Mountain southeastward into the San Luis quadrangle. The lower part of the sequence found here contains a fauna typical of the Paskenta group. Fairbanks (1895b) has described the beds occurring on the south slope of Pine Mountain, referring to them as "Knoxville," but later study of the fossils obtained there by Fairbanks and the writer (1895) prove them to be of Paskenta age. They include *Aucella crassa*, *A. inflata*, and *A. uncitoides*, and were found in calcareous concretionary layers in a dark clay shale. From here the beds can be traced into the "Toro formation" in the San Luis quadrangle of which they constitute the major part. From the account of the "Toro formation" given by Fairbanks (1904), it contains no strata older than the Paskenta. If Knoxville beds occur about Pine Mountain or north of San Luis Obispo, it seems probable that they will be found to underly the Paskenta and to rest upon, or against, the Franciscan (San Luis) formation. But no final account of these deposits can be made without the proper discrimination of these two series.

Santa Barbara County.—In the region of complicated structures along the upper branches of the Santa Ynez River, considerable areas of Mesozoic sediment have been described by Kew (1919), and later by Nelson (1925). In part these Mesozoic deposits are referable to the Knoxville series, and in part to the Paskenta group of the Shasta series. Quoting from the account given by Nelson, he writes:

> "From the occurrence of both *Aucella piochii* and *Aucella crassicollis*, it is inferred that the Knoxville as mapped, includes both the lower and upper divisions recognized elsewhere in California."

It appears from Nelson's account that the upper division of the so-called "Knoxville" in this region is in fact the Paskenta group of the Shasta series and that the lower division is properly referable to the Knoxville series, as understood in this memoir.

OREGON CRETACEOUS AREAS

General Statement.—The marine embayments in southwestern Oregon in early Cretaceous time extended into the coastal valleys then existing and also into the more inland valley of the Umpqua River (Dillard, Myrtle Creek, and Riddle areas), and into the valley of the Illinois River. Only in later epochs did it enter the central valley of the Rogue River, farther to the east.

The Myrtle Formation.—The "Myrtle formation" was first described by Diller (1898) as including the Cretaceous deposits along Myrtle Creek,

Douglas County, Oregon. It was thought to be in large part equivalent to the "upper Knoxville" beds in California on account of its fauna. The term was later applied to similar deposits in the Coos Bay and Port Orford areas (Diller 1903b). The formation was later reviewed by Diller (1908) and somewhat modified so as to include also the "lower Knoxville." In the text of the Port Orford folio, as well as in his later contribution, Diller seems to have recognized two or more distinct stratigraphic units within its span, although he did not go so far as to separate them. One of these units was said to be characterized by abundant plant remains and by the occurrence in it of *Aucella piochi* Gabb; the other was composed of conglomerates and sandstones, as on Elk River, Curry County, and carried the following molluscan fauna:

Aucella crassicollis Keyserling
Turbo morganensis Stanton
"Hoplites" hyatti Stanton
Inoceramus ovatus Stanton
"Olcostephanus mutabilis" Stanton
Belemnites tehamaensis Stanton ?
Belemnites impressa Gabb

Of the seven species in this list, six are typical of the Paskenta group in the Shasta series of California. As no species referable to the Knoxville series (*s. s.*) was positively identified, we may accept the formation as properly representing the Paskenta. Thus it appears that the "Myrtle formation" in Oregon is in large part equivalent to the Paskenta group of the Shasta series in California.

The lower part of the "Myrtle formation" containing *Aucella piochi* Gabb may be accepted as coming within the limits of the Knoxville series, provisionally at least. The proper division of the "Myrtle formation" into Lower Cretaceous and upper Jurassic portions constitutes an important task for future exploration and mapping, and this will doubtless be facilitated by the careful work of both Diller and Stanton.

In the discussion of the "Myrtle formation" in the Port Orford quadrangle by Diller, it is readily seen that the strata containing *Aucella crassicollis* and associated forms rest in some places upon beds containing *Aucella piochi* and in other places directly upon metamorphic rocks (schists, serpentine, and gabbros), with neither Dothan nor Knoxville beds intervening, as is often the case with the Paskenta group in California.

Another part of the "Myrtle formation" may represent the Horsetown group, in part, as may be seen from the lists of species given by Stanton (1895, p. 22, 23) from near Riddle. Of some 16 species listed by him, half of them are known to occur in this group; some of them also occur in the lower part of the Chico series in California.

On the map of the Riddle quadrangle (Diller and Kay, 1924), in most places where the "Knoxville" beds are shown in contact with older rocks, the latter belong to the basement complex, and no other rocks intervene.

As far as can be determined the so-called "Knoxville" are, in most instances at least, no other than equivalents of the Paskenta group. In the account given by Stanton (1895, p. 22, 23) he states that

> "The Cretaceous rocks here, covering an area about 5 miles long and 3 miles wide, are in contact with metamorphic rocks on the east and with serpentine and peridotites on the west. The strata at most exposures have a steep dip and seem to form a syncline, complicated perhaps by faults or minor folds."

The same view is expressed by Diller and Kay (1924) and has been confirmed by the writer's personal inspection during a more recent visit. Following this visit, E. L. Packard of the Oregon State College sent to the California Academy of Sciences a considerable collection of well-preserved and diagnostic fossil Mollusca from beds exposed near Riddle, which throw much light upon the age of the sequence occurring here. Many of the species found here are described in this memoir for the first time. The following list includes the more important of these fossils:

Phylloceras trinitense nov.
P. occidentale nov.
P. umpquanium nov.
P. regonense nov.
Aucella crassa Pavlow
A. crassicollis Keyserling
A. lahuseni Pavlow
A. inflata Toula
Dichotomites oregonensis nov.
Lyticoceras packardi nov.
Hoplocrioceras cf. *onoense* nov.
Neocomites riddlensis nov.
Venus collinae nov.
Pleuromya laevigata Whiteaves
Periploma cf. *reddigensis* nov.
Pecten (Syncyclonema) sp.

To this list may be added *Berriasella hyatti* (Stanton) and *Acroteuthis impressa* (Gabb), as reported by Stanton (1895, p. 22, 23). The Lower Cretaceous (Paskenta) age of the strata from which these fossils were taken can hardly be doubted. Many of the forms named in this list are common in the Paskenta group in California, and near analogues of others are found in it. Some of them have also been found in the Horsetown group.

In 1913 Bruce G. Martin obtained a small collection of fossils from a point 2 miles north of the mouth of Myrtle Creek, including *Aucella crassa* Pavlow, *A. lahuseni* Pavlow, and *A. terebratuloides* Lahusen. All these species pertain to the Paskenta group of the Shasta series in California.

In the beds occupying the syncline at Riddle, no strata older than the Paskenta group have been shown to exist, although older beds have been reported. From near Nichols station, some miles southwest of Riddle, Diller (1908, p. 375) has reported beds containing "typical specimens of *Aucella piochi* Gabb" and Mesozoic plants. The resemblance of the young stages of other forms of *Aucella* to *A. piochi* Gabb necessitates a degree of caution in their determination, and therefore of reserve in the acceptance of hasty identification.

In the Dillard area north of Myrtle Creek (town), the "Myrtle formation" extends over most of the area covered by the Roseburg quadrangle,

although little information has been given as to its thickness or stratigraphical limitations. According to Diller the "Myrtle formation" in this district contains beds of conglomerate, sandstone, limestone, and shale. Small limestone areas have been mapped and described as the "Whitsett limestone lentils," in which are found a few imperfect fossils, among which Stanton (Diller, 1898) recognized *Opis californica* and a species of *"Hoplites"* closely related to, or identical with, *"H." dilleri* Stanton. In the sandstone, within 300 feet of the "Whitsett limestone" in its type area, well-preserved specimens of *Aucella crassicollis* were reported. Concerning this limestone, Diller says, in part:

"The occurrence of limestone in the upper part of the Knoxville of the Dillard area is not exceptional, for it occurs at that horizon in several places along the west side of the Sacramento Valley in California."

In this text the "upper part of the Knoxville" refers to the Paskenta group in which limestone of the same kind occurs in lentils on the west border of the Sacramento Valley. All the fossils clearly identified in Diller's notes have been found in the Paskenta group in California, and no clear evidence of older beds associated with the "Whitsett limestone lentils" has been recorded.

Probably most of the conglomerates found in the Dillard district occur in the lower part of the Paskenta group, and they might be taken as indicating its unconformity upon older formations. In the Dillard area the same uncertainty regarding the occurrence of Knoxville strata exists as about Riddle. Further investigation is needed to determine what stratigraphic groups are included in the "Myrtle formation," as it has been mapped. The same also appears to be true in other areas in western Oregon where Knoxville beds have been reported. In the Riddle area the oldest clearly determined Cretaceous strata contain *Dichotomites*, *Lyticoceras*, *Neocomites*, *Aucella crassicollis*, and other forms of Valanginian age, and therefore belong to the Paskenta group.

If any Knoxville beds occur in this district they may include the lowest, plant-bearing beds in the "Myrtle formation" about Buck Peak, described by Diller, though they contain only a scanty suggestion of the rich Tithonian faunas found on the west border of the Sacramento Valley. Their determination as Knoxville can hardly be regarded as conclusive, although future collections of molluscan and plant remains from these beds may fix their age as definitely Jurassic (Tithonian).

There is little known evidence that Horsetown beds (Hauterivian to Albian) occur in any of the Cretaceous basin areas of southwestern Oregon. No published record has been found of the occurrence of rich cephalopod faunas here such as are known in the Great Valley of California and in Canadian and Alaskan areas farther north.

MORE NORTHERN AREAS

In the State of Washington various localities have yielded invertebrate fossils referable to the Paskenta group. White (Becker, 1888) has figured an example of *Aucella* from western Washington which Pavlow has regarded as *A. solida*, a form that is abundant in the Paskenta group of California. Diller has noted *Aucella*-bearing rocks in different parts of the State (Cascade Range and Vashon Island). Lower Cretaceous deposits have been described from the Nooksak River north of Mount Baker, farther to the east upon the Pasayten River, and in the Hozomeen Range in northern Washington. Little is known concerning the faunas of these beds, although *Aucella crassicollis* is said to occur in each of these localities. In the Hozomeen Range the steep dips indicate a stratigraphic thickness of at least 6000 feet of black shale and overlying conglomerates.

SAN JUAN ISLANDS

R. D. McLellan (1927) describes isolated outcrops of conglomerate, sandstone, and shale occurring on the San Juan Islands, which he includes in the Spieden formation. Its principal area is on Spieden Island, adjacent to San Juan Island on the north. According to McLellan, conglomerates make up 85 per cent of the rocks within the area mapped as the Spieden formation. He adds:

> "Along the northern margin of Spieden Island there is a group of thin-bedded and somewhat carbonaceous shales." These "grade upward into sandy shales and sandstones with an occasional bed of argillaceous limestone. . . ."
> "Throughout a thickness of about 35 feet these beds are richly fossiliferous."

These layers are overlaid by a succession of strata 2000 feet in thickness in which conglomerates greatly preponderate. The fossil-bearing beds of Spieden Island have yielded many invertebrate species including the following, as described by McLellan (1927, p. 114).

Aucella crassicollis Keyserling
Holcodiscus ? stantoni McLellan
Phylloceras spiedenense McLellan
Pleuromya typa McLellan
P. thor McLellan
Lima spiedenensis McLellan

According to McLellan, *Aucella* constitutes 95 per cent of the fauna, and he adds:

> "The fauna was examined by Dr. T. W. Stanton, who determined its age to be Lower Cretaceous, and equivalent to the upper part of the Knoxville formation of California."

As the upper part of the "Knoxville formation" in California, bearing an equivalent fauna, is included in the Paskenta group of the Shasta series, the Spieden formation should be interpreted accordingly.

From the figures given by McLellan, "*Holcodiscus ?*" *stantoni* appears to belong to the genus *Dichotomites* of Spath, near *Dichotomites fragilis* as illustrated by Pavlow.

A small collection of fossils from the north side of Spieden Island, ob-

tained by W. W. Wells of Ashland, Oregon, includes *Aucella crassicollis*, *A. crassa*, *Phylloceras spiedenense*, and *Dichotomites*, near *Dichotomites tehamaensis* nov., from the Paskenta beds on the Wilcox ranch, Tehama County, California.

BRITISH COLUMBIA

Lower Cretaceous deposits comparable to the Shasta series have been described from many places on the mainland (Harrison Lake, Tatlayoco Lake, and Jackass Mountain) and also from some of the offshore islands (Vancouver Island and Admiralty Island) (Wright, 1906). From the district of Harrison Lake, Crickmay (1930) has described Mesozoic deposits with many species of *Aucella*, which he regards as Lower Cretaceous in age. Many of the Aucellan forms illustrated by him bear close resemblance to species found in the Paskenta group in western Tehama County, California. Some of them appear to belong to the groups of *Aucella inflata* Toula, *A. keyserlingi* Lahusen, and *A. crassa* Pavlow. From Quatsino Sound, Whiteaves (1883, p. 81–83) has described *"Olcostephanus" quatsinoensis*, which seems to belong to *Polyptychites*, a genus well represented in the Paskenta group in California. From the same area he has also figured *Inoceramus quatsinoensis*, a species similar to, if not identical with, *Inoceramus elliotl* Gabb, here recognized as a Lower Cretaceous fossil apparently belonging to the group of *Inoceramus ovatus* Stanton, found in the Paskenta group in its type district and in the Cottonwood district in Shasta County.

ALASKA

Many references to Lower Cretaceous deposits in Alaska are found in the geological literature of the Territory, not all of which can be noted here. Many of the accounts that have been found leave much to be desired as to their major features, age determinations, relationships, and their distinctness from other formations. Still there is undeniable evidence that equivalents of both Paskenta and Horsetown groups occur in many of its areas. The general distribution of Lower Cretaceous rocks in Alaska has been briefly stated by Martin (1926, p. 288) as follows:

> "The rocks that have been referred to the Lower Cretaceous include the Staniukovich shale and the Herendeen limestone of the Alaska Peninsula; conglomerate tuff and arkose and the overlying Nelchina limestone of the Upper Matanuska Valley; the shale, sandstone, and conglomerate of the Kennicott formation of the Chitina Valley; some of the *Aucella*-bearing shale and graywacke of Chisana and White rivers; some of the *Aucella*-bearing slate and associated rocks of southeastern Alaska; the *Aucella*-bearing shale and sandstone of the Upper Yukon and Rampart-Tanana district; the limestone, chert, and arkose of the 'Oklune series' of the region north of Bristol Bay; the limestone, shale, and sandstone of the Koyukuk group of the Koyukuk Valley; and the sandstone and conglomerate of the Anaktuvuk group of northern Alaska."

In the later discussion of these areas the faunal characteristics of the various formations referred to the Lower Cretaceous are probably not

complete, although there are many references to the occurrence of *Aucella crassicollis* Keyserling and to a few other forms that occur in the Shasta series of California. Wherever *Aucella crassicollis* occurs in these several accounts it may be taken as evidence of the early Cretaceous age of the beds, but perhaps not always of the Paskenta (Valanginian) age.

FEATURES OF THE HORSETOWN GROUP

Type District.—The Horsetown group[4] is typically developed in the Cottonwood district north of the delta axis. Its stratigraphical relations at both top and bottom are best shown here, and it is best supplied with diagnostic invertebrate fossils and with faunal zones which range throughout its stratigraphical sequence in such a way as to make it of unusual value for faunal and chronological study. When taken together with the faunas of the Paskenta group they give to the district an interest and importance not yet found in any other West Coast area for showing the faunal character and the faunal succession throughout its Lower Cretaceous sequence. Indeed, this district could well supply a standard reference column for the Lower Cretaceous faunas in all parts of the Pacific Coast and aid in correlations of strata much farther.

Like the immediately older group, the Horsetown group in this district becomes progressively thicker when followed southward from the North fork of the Cottonwood Creek toward the delta axis, increasing from a thickness of 6430 feet near Ono to more than 12,500 feet in its maximum section. In all sections north of the delta the group begins at the bottom with conglomerate beds which in some places make up a large percentage of its lower portion, but which for the most part are lenticular. Near Ono there is only a single bed of conglomerate, about 60 feet thick, but a few miles to the south three beds appear, and on Roaring River there is a succession of four such beds within a stratigraphical thickness of 1000 feet. When traced farther south these beds pass into the sandstones and sandy shales of the delta axis and disappear. South of the delta similar conglomerate beds appear near the base of the group and become conspicuous on the Cold fork of Cottonwood Creek. The single bed found at Ono is probably not the lowest one of the series. Immediately beneath it there is a richly fossiliferous zone of thin-bedded sandstones, 200 feet thick, which can be traced eastward to Eagle Creek, and which may be known as the Ono zone. This zone forms a near-basal part of the Horse-

[4] It may be noted here that the term Horsetown, as a formational name for the succession of strata to which it has been applied, is not a happy choice. The area about the old mining camp of this name is detached from the district in which the group is most typically and completely represented and at best exposes not more than 500 feet of the uppermost beds of the Shasta series, which beds are scarcely representative of the great body of older strata included under the name by White, Stanton, and Diller, and by later writers. Although the name is retained for the group in the present memoir, it is only its use in the literature of the past that justifies its continuance as a formational name. The term Cottonwood group would have been far more appropriate for it.

town group and the oldest part of the Hauterivian stage in the Cottonwood district.

No clearly marked stratigraphical break between the Paskenta and Horsetown groups has been found here, although the conglomerate beds extending south from Ono may be taken as such. Otherwise, only an arbitrary line has been drawn for it. The rich fauna of the Ono zone at the bottom of the Horsetown group seems to represent a low Hauterivian horizon on the scale of Europe, and for this reason it forms a convenient reference plane, serviceable for correlation, and it is believed that the sequence of faunas in the Cottonwood district above and beneath it fully supports this view. In the district of Thomes and Elder creeks, Tehama County, the exact equivalent of the Ono zone has not been found, although it is probably a little below the horizon of "Zone R" of the McCarthy Creek section (Anderson, 1933, opp. p. 1242). This is indicated by some of the species named by Stanton and by various molluscan forms found by the writer.

In the Cottonwood district, above the conglomerate overlying the Ono zone, there is a thick succession of sandstones, sandy shales, and argillaceous shales, totaling 6500 feet of strata as exposed along the stream east of Ono and on Hulen Creek, a northern tributary of it. The uppermost bed of the Horsetown group in this section crosses the North fork and also Hulen Creek, about half a mile above their junction. On both streams the Horsetown group is overlaid unconformably by the basal beds of the Chico series. East of the east branch of Hulen Creek the Cretaceous beds are covered by the Tehama formation, consisting of volcanic tuffs.

Five miles northeast of Hulen Creek the canyon of Clear Creek has cut through the Tehama formation, exposing the uppermost beds of the Horsetown group at the site of the old mining camp of this name, and also at Jackass Flat, a mile or more east of Horsetown. The horizon exposed at Texas Springs may be above its upper limit, although many of the species found at Horsetown also occur here.

Southward from the North fork of Cottonwood Creek many of the more characteristic fossil zones of the Horsetown group may be recognized upon all the streams coming from the west, and the group can be traced across the delta areas and as far south as Redbank, Elder, and McCarthy creeks, and as far as the valley of Berryessa Creek. South of the delta axis, east of Stephenson's on the Cold fork, conglomerate beds similar to those on the North fork seem to occupy the basal part of the Horsetown, although the stratigraphic details have not been studied here. South of McCarthy Creek the Horsetown group has been recognized only by its stratigraphical relations at top and bottom, although several diagnostic fossils have been found in it.

The top of the Horsetown group is indicated generally by the basal beds of the Chico series, resting unconformably upon it, and by them it is more easily followed. The basal conglomerates of the Chico series are recognizable on most of the streams between Hulen and Elder creeks, and in many places by distinctive fossils. South of Dry Creek the Chico series is often overlapped extensively by the Tehama formation or is exposed only in the canyons of the larger streams (Cold fork, Redbank, and Elder creeks).

In the Lodoga Hills, conglomerates mark both the top and bottom of the Horsetown group, of which only the top has been followed far in the field. These beds seem to indicate epochs of disturbance and of readjustment of strandlines at the beginning and close of Horsetown sedimentation, but not everywhere of equal effect. More striking evidences of disturbances, if not of unconformity, are seen in the faunal changes that appear in the sections in passing from Paskenta to Horsetown, and from the latter to the lower beds of the Chico series. These disturbances appear to have been of great geographical extent along the Pacific Coast, reaching from Lower California to Alaska, and probably affected Mexico and the northern Andes (Colombia and Venezuela).

The time intervals represented by these unconformities cannot be measured but, as indicated by the faunal changes effected, they seem to have been long, although in some places sedimentation seems to have been nearly continuous from Paskenta to Horsetown times, but not so between the latter and Chico times. In many places the unconformity of the Chico series upon the Horsetown, or upon Paskenta beds, is marked by evidences of erosion, with the transportation of materials and fossils from older beds into the basal conglomerates of the Chico series.

DIVISIONS OF THE HORSETOWN GROUP

General Statement.—For convenience in the discussion which follows, the Horsetown group is here divided into two major portions, namely, the Cottonwood beds below and the Hulen beds above, each division being more typically represented in its outcrops on these streams. In each division there is a succession of distinctive faunal zones not found in the other. Together these zones present a faunal sequence comparable to that in corresponding horizons in any other part of the world. In addition to the criteria supplied by each zone for chronological purposes its contribution to a general scale is supported and reinforced by those of other zones above and beneath, throughout the entire group. Neither of these divisions has been recognized as such beyond the limits of the Great Valley embayments.

Cottonwood Beds.—In their type district the Cottonwood beds form a belt 2½ miles broad, crossing the North and Middle forks of Cottonwood

Creek. From the latter stream the belt extends in a southwest course to Dry Creek, northern Tehama County, and thus across the delta area. On the North fork the beds have a thickness of about 3480 feet, but they thicken rapidly toward the southwest and occupy a correspondingly broader zone. On Dry Creek, a few miles south of the delta axis, their thickness is about 8400 feet, and their zone is not less than 4.2 miles broad, measured across the strike. Farther south the beds become thinner and their zone narrower. On McCarthy Creek, the thickness is 7660 feet, and the zone has a breadth of 2.5 miles, but the angle of dip is somewhat greater.

The basal conglomerates of the Horsetown group are for the most part lenticular, although on the whole they form a fairly well defined geological and topographical belt which extends for many miles through the Cottonwood district. In the lower part of this belt, as at Ono, is the earliest faunal zone of the Horsetown group, namely, the Ono zone. Its fauna is for the most part quite distinct from that of the Paskenta group and is well represented near the bridge on the North fork at Ono, Locality 1353 (Calif. Acad. Sci.), and at the same horizon on Eagle Creek, half a mile east of the bridge. The following composite list of species from these points represents less than 200 feet of strata:

Lytoceras traski nov.
Phylloceras occidentale nov.
Crioceras latum Gabb
Acroteuthis onoensis nov.
Inoceramus colonicus nov.
I. ovatoides nov.
Pleuromya papyracea Gabb
P. altumbonata nov.
Aphrodina cf. *nitida* (Gabb)
Ampullina avellana (Gabb)
Potamides diadema Gabb
Tessarolax bicarinata (Gabb)
Lytoceras aulaeum nov.
Neocraspedites aquila nov.
Haplocrioceras remondi (Gabb)
Acroteuthis kernensis nov.
Plicatula varia Gabb
Nemoden breweriana (Gabb)
Astarte californica Stanton
Corbula filosa Stanton
Pecten (*Syncyclonema*) sp.
Nerinea archimedi nov.
Turbo festivus nov.
Diastoma occidentalis Stanton

Only a small number of these species appear in the Paskenta group in the Cottonwood district; a few others occur in it in its type district and on the Cold fork of the Cottonwood, near Stephenson's.

Where this zone crosses Roaring River it is not directly recognizable, but its position is indicated by fossil zones found above and beneath it and by basal conglomerate beds, as is the case farther south. This zone is not younger than early Hauterivian, as evidenced by the presence of *Neocraspedites aquila*, *Haplocrioceras remondi*, *Crioceras latum*, and species of *Acroteuthis*. To these may be added *Inoceramus colonicus*, *I. ovaloides*, *Astarte californica*, and *Corbula filosa* Stanton, all of which seem to lend support from their occurrence in other sections.

In the Roaring River section above the lower Horsetown conglomerate is a thick succession of sandy shales overlaid by shales almost without sandy material. In the clear shales, about 1650 feet above the second conglomerate and 1850 feet above the position of the Ono zone, is found

the zone containing Locality 1661 (Calif. Acad. Sci.), which crosses Roaring River about 840 feet west of the Millsap road. About 250 feet west of this road Popenoe and Scharf collected *Acroteuthis shastensis* nov. and *Pulchellia popenoei* nov. A mile farther south on a tributary of Roaring River the following species were collected by R. D. Russell and the writer from Locality 1661, which lies a few hundred feet lower:

Shastlerioceras poniente nov.
Ancyloceras durrelli nov.
Hoplocrioceras wyntoonium nov.
Acroteuthis impressa (Gabb)
Pseudocrioceras stentor nov.
Acrioceras starrkingi nov.
Lytoceras cf. argonautarum Anderson
Inoceramus colonicus nov.

The Mitchell zone, which may include a stratigraphical thickness of 200 feet, begins about 150 feet above the horizon of Locality 1661. It has been traced for a distance of 2 miles on either side of Roaring River and has been identified as far north as the North fork, and as far south as Dry Creek. A composite list of species obtained from it near Roaring River includes the following:

Shastlcrioceras hesperum nov.
S. poniente nov.
Hoplocrioceras whitneyi nov.
Phylloceras occidentale nov.
Ptychoceras natrice nov.
Acroteuthis shastensis nov.
Ancyloceras elephas nov.
A. ajax nov.
A. altrax nov.
Hemibaculites nelius nov.
H. nauplius nov.
Inoceramus ovatoides nov.

About 650 feet above the Mitchell zone is the Barr zone, locally characterized by a thin pebbly, tuff-like conglomerate 8 to 10 feet thick, the whole having a maximum thickness of 30 feet. It has been traced from Roaring River north for 2 miles, beyond which point it is covered by alluvium. On Hulen Creek this zone is thought to be represented by the conglomerate at the gorge on the west branch of this stream. From this zone the writer has obtained:

Gabbioceras angulatum Anderson
Shastoceras shastense nov.
Nautilus averilli nov.
Acroteuthis aboriginalis nov.
Terebratula averilli nov.
Parahoplites stantoni nov.
P. dallasi nov.
Pecten californicus Gabb
Neithea grandicosta Gabb
Aucella radiostriata nov.

The Argonaut zone, named for the pioneer settlers of this region, is the next important zone above the Barr conglomerate. The interval between is about 150 feet, as found in the Mitchell Creek district. It consists lithologically of dark or slate-colored shales, similar to those of the Mitchell zone, but its fauna is distinctly different, as may be seen from the following list of invertebrates obtained from it at Locality 1347 (Calif. Acad. Sci.), a little east of Mitchell Creek:

Lytoceras argonautarum Anderson
L. traski nov.
L. batesi (Trask)
Phylloceras onoense Stanton
Tropaeum percostatum (Gabb)
Australiceras argus nov.
Gabbioceras wyntunium nov.
Parahoplitoides shoupi nov.
P. cerrosensis nov.
P. senitoides nov.
Hemibaculites mirabilis nov.
Shastoceras, sp. nov.

From this zone on Hulen Creek came the holotype of *Lytoceras argonautarum* Anderson and probably also that of *Lytoceras batesi* (Trask), although differently recorded by Gabb (1869a, p. 127). On Hulen Creek this zone is underlaid by the pebbly conglomerate at the outlet of the gorge 2 miles above the mouth of the creek, and is thought to represent the Barr zone, which at its type locality is similarly situated faunally.

The Alderson zone, 100 to 300 feet above the Argonaut zone, is best exposed on the main branch of Alderson Creek, 2 miles south of Ono, and also on the Shoup ranch on Bee Creek, a little farther south. Its stratigraphical thickness, as found near the forks of Alderson Creek, is about 100 feet. It has been recognized at a number of points between Hulen Creek and the Middle fork of the Cottonwood and has been found on Dry Creek and probably also on McCarthy Creek, Tehama County. Many of the species described by Gabb seem to have come from this zone on Alderson Creek and from the North fork of the Cottonwood, east of Ono. The following list of species is somewhat composite, but it probably correctly represents the zone between Ono and Roaring River:

Phylloceras aldersoni nov.
Lytoceras batesi (Trask)
Melchiorites shastensis nov.
Desmoceras voyi Anderson
Cheloniceras cf. *hindsi* nov.
Acanthoplites aegis nov.
Parahoplites macfarlandi nov.
Shastoceras californicum nov.
Hamiticeras aequicostatum (Gabb)
Hemibaculites cyclopius nov.
Acanthoplites gardneri nov.
Fossil wood?.

Some species found in this zone occur also in the Argonaut zone, but most of them are found here for the first time, such as *Shastoceras californicum*, *Melchiorites shastensis*, *Hamiticeras aequicostatum* (Gabb), and *Desmoceras voyi* Anderson. About 200 feet above the Alderson zone was found the holotype of *Hamulina aldersona* nov. which as far as known is the only example of the species yet found.

Species occurring in the above list have been found as far south as McCarthy Creek, including *Melchiorites shastensis*, *Cheloniceras* cf. *hindsi*, *Lytoceras batesi* (Trask), and probably *Phylloceras aldersoni*.

The Reeside zone, best known on Hulen Creek, is about 750 feet (est.) above the horizon of *Hamulina aldersona*, and 1200 feet above the Argonaut zone, found on both Hulen and Alderson creeks. The Reeside zone is the highest fossil-bearing zone of the Cottonwood beds and appears to represent the later part of Aptian time. Thus far only a few species have been obtained from it, namely:

Cheloniceras reesidei nov.
Cheloniceras irregulare nov.
Acanthoplites cf. *spathi* nov.
Much fossil wood

The top of the Cottonwood beds is believed to represent the close of Aptian time, although this may be subject to doubt. Species of *Parahoplites* and of the related genus *Acanthoplites* have been obtained from Alderson Creek, east of its principal branch and therefore above the

Alderson zone. Some of these were collected by G. W. McFarland, a part of whose collection was purchased by the California Academy of Sciences.

Hulen Beds.—The boundary between the Cottonwood beds and the lowest of the Hulen beds is perhaps one of paleontological distinction only at present, although there are certain lithological changes found in the Hulen Creek section, in which the upper part of the Horsetown group is most fossiliferous. The area in which these beds are best known lies north of the North fork of the Cottonwood Creek and is traversed by the eastern branches of Hulen Creek, whence the name is taken. Here the Hulen beds are overlaid by the lowest beds of the Chico series. A little farther east both are covered by the Tehama formation, and the Hulen beds do not appear again south of Clear Creek with the same faunal development, although they have been found south of the delta area and reappear at intervals south of Elder Creek, and in the Diablo Range a few of their characteristic fossils have been found.

In their type area the lower part of the Hulen beds consists of dark argillaceous shales, with only occasional layers of sandstone and sandy shales and zones of calcareous concretions in which there are many fossils. These concretions vary in size from 2 inches to 2 feet in diameter, many of them being melon-shaped. Many of them contain ammonites or other molluscan fossils in an excellent state of preservation; others contain only fossil wood, but most of them are barren. Among the plant remains a few fossil branches, leaves, and nuts of coniferous trees have been found.

The lowest fossil-bearing zone of the Hulen beds, here called the Buenaventura zone, occurs about 300 feet above the Reeside zone of the Cottonwood beds. It has been identified as far south as Roaring River and indirectly on Dry Creek, south of the delta.

Among its typical invertebrate fossils are the following:

Puzosia buenaventura nov.
P. reesidei nov.
Desmoceras diadema nov.
Cheloniceras sp.
Douvilleiceras mammillatum var.
Silesites puzosiaformis nov.
Acanthoplites spathi nov.
Venus corella nov.

This zone is best exposed on the west branch of Hulen Creek, about a mile above its mouth, where it is characterized by many large concretions.

About 400 feet above the Buenaventura zone was found the holotype of *Puzosia dilleri* (Anderson), a distinctive form between *P. buenaventura* and *P. subquadrata* (Anderson).

The Bradley zone, about 730 feet above the Buenaventura, is represented by the following list characterized by species of *Cheloniceras*. It contains:

Cheloniceras bradleyi nov.
C. stoliczkanum (Gabb)
Acanthoplites barryana nov.
Turnus plenus Gabb
C. populorum nov.

The holotype of *Cheloniceras stoliczkanum* (Gabb) probably came from this zone which has recently yielded an immature example of it. No evidence of this zone has been found south of the North fork of the Cottonwood Creek.

The Le Conte zone, 1000 feet or more above the Buenaventura, has yielded a small fauna of distinctive cephalopods, among which are:

Cleoniceras leconteï (Anderson)
C. modestum nov.
C. sp. nov.
Acanthoplites perrini nov.
Sonneratia rogersi Hall and Ambrose
Nautilus gabbi Anderson

The Perrin zone, about 1400 feet above the Buenaventura and about 800 feet below the top of the Hulen beds (local base of the Chico series), contains a larger fauna than the preceding zone, including:

Sonneratia perrinsmithi nov.
S. sacramentica (Anderson)
S. taffi nov.
S. mulleri nov.
Phylloceras theresae nov.
Diptychoceras laeve Gabb
Hamites imitator nov.
Anchura biangulata nov.
Nemodon breweriana (Gabb)
Pinna equivillana nov.
Pholadomya hulenana nov.
Crab remains
(?) *Ptiloteuthis foliatus* Gabb

It is likely that the holotype of *Acanthoplites remondi* (Gabb) was found in this zone, although no example identifiable with it has yet been found. According to Gabb's (1869a, p. 127) note, *Ptiloteuthis foliatus* and *Callianassa stimpsoni* Gabb were probably also found in this zone. Crustacean remains have been found in, and also beneath it.

The Neptune zone, so named from a large species of *Lytoceras* found in it, is the highest fossil-bearing zone of the Hulen beds in their type area, although perhaps not so high as that at Horsetown itself. It is exposed along the east branch of Hulen Creek and about 450 feet beneath the lowest beds of the Chico series, which here overlaps the Horsetown group. The Neptune zone is here lithologically unlike any of the preceding zones, being composed of a dark sandy, tufaceous material without much clay or calcareous matter, although concretionary shales crop out immediately beneath it. The thickness of the Neptune zone is apparently limited to 80 feet and is succeeded above by sandstones and sandy shales, upon which rest the basal beds of the Chico series. The Neptune zone has been identified at other points farther south (Dry Creek, Elder Creek, Willow Creek, and Puerto Creek). At Locality 1659 (Calif. Acad. Sci.), on the east branch of Hulen Creek, the following species have been collected:

Lytoceras neptunium nov.
L. aurarium nov.
Gaudryceras duvaliforme nov.
Douvilleiceras mammillatum var.
Nemodon breweriana (Gabb)
Pinna equivillana nov.
Panopea concentrica Gabb
Beudanticeras breweri (Gabb)
B. hulenense nov.
Desmoceras merriami (Anderson)
Puzosia subquadrata (Anderson)
Terebratula ovula nov.
Pecten (Syncyclonema) operculiformis (Gabb)
Turnus gregarius nov.

The chronological position of this zone is regarded as upper-middle Albian, as judged by the presence in it of *Beudanticeras* and *Douvilleiceras*, as well as the contents of the zones beneath it in its type district and certain fossils above it.

From the concretionary shale immediately beneath was obtained a large example of *Phylloceras*, of the group of *P. velledae* Michelin. Of the fourteen species named, eight have been found at Horsetown and vicinity, and with them a few that seem to represent a somewhat higher horizon, such as *Beudanticeras haydeni* (Gabb) and *Nautilus charlottensis* Whiteaves. Both occur in the lowest beds exposed at Horsetown and have also been collected with *Pervinquieria inflata* var. from transported material at the mouth of Hulen Creek, a little above the horizon of the Neptune zone.

The Packard zone, exposed on Alderson Creek 2 miles south of Ono, appears to be a little higher in the section than the Neptune zone. Among its representative fossils, a few were obtained also at Horsetown. The list includes:

Oxytropidoceras packardi nov.
Douvilleiceras mammillatum var.
Beudanticeras breweri (Gabb)
Puzosia hoffmanni (Gabb)
P. cf. *planulata* (Sowerby)
P. aldersona nov.

From the foregoing account of the successive zones in the Shasta series in the Cottonwood district, it will be seen that they exhibit a faunal order which ranges from the little-known Valanginian of the Paskenta group through the several stages of the Horsetown (Hauterivian to Albian), and ending only at the overlap of the Chico series, whose earliest beds with *Pervinquieria inflata* var. *Beudanticeras haydeni* (Gabb) and rudistid species are of late Albian age.

It is not supposed that the faunas belonging to any of these zones are completely known or that other zones of equal importance may not be found later. It is hoped that enough is here given to indicate the stratigraphical span of the Shasta series and to illustrate the faunal order of its several zones as a basis for the general correlation of strata found in other areas of the Great Valley, in neighboring troughs, and in more distant areas on the Pacific Coast, or elsewhere. If better grouping of the faunas may eventually be arranged, or the zones may be better illustrated or named, the results will be welcomed by the writer as much as by others.

RESTRICTED HORSETOWN AREAS

General Statement.—The Horsetown group is most completely developed on the western border of the Sacramento Valley, but beyond these limits its distribution is small and its stratigraphic thickness much reduced. Fossils representing only a small part of the group have been found in other places, but its most representative faunas are lacking. In the

region about San Francisco Bay (Point San Pedro, Los Gatos, Hayward, and Corral Hollow), fossils have been found which are referable to some part of the Horsetown, but the sections are much reduced and the fossils few. In Oregon, also, only meager evidences of the Horsetown group have been recorded, as in the valley of Rogue River (Illinois Valley), and in the valley of the Umpqua River (Riddle, Myrtle Creek, and Dillard), and on Elk River, Curry County. No evidence has been recorded that Horsetown deposits occur in northern Oregon, or in any part of Washington, although they seem to occur in British Columbia at a few places.

Queen Charlotte Islands.—The Cretaceous deposits of Queen Charlotte Islands and their faunas are yet only imperfectly known, although they appear to be richly fossiliferous. Most of the Mesozoic invertebrates described from these islands have been regarded as either Jurassic or Upper Cretaceous in age, and scant information has been found concerning Lower Cretaceous there. After considerable exploration and an extended study of the geology of Graham Island, MacKenzie (1916) recognized only the "Queen Charlotte series" and its divisions proposed by Clapp, namely, the Haida, Honna, and Skidegate formations. Concerning this series MacKenzie (1916, p. 65) says, in part:

> "The fossils from the Queen Charlotte series show these rocks to be of Upper Cretaceous age, and Dr. Stanton states that most of them, judged by European standards, are no older than the Gault."

This opinion is supported by the lists of fossils given by MacKenzie, but these lists should not be regarded as evidence that Lower Cretaceous deposits do not occur on the island. Whiteaves has figured and described from these islands many fossil invertebrates of Lower Cretaceous age which are either identical with, or are near analogues of, molluscan species occurring in the Horsetown group, as noted by Stanton (1894, p. 461).

Without claiming to possess a satisfactory knowledge of the stratigraphy of these islands, the following notes are offered as a contribution to their paleontology. They are intended to indicate only that strata older than the Gault do occur there and form a considerable part of their stratigraphic column. The following species have been noted or described by Whiteaves (1876):

Pleurotomaria skidegatensis and *Nerinea maudensis* Whiteaves were said to have been found on Maude Island, although they do not appear in any of the lists of MacKenzie. They have near analogues in the lower part of the Horsetown group in the Cottonwood district of Shasta County, California.

"Lytoceras batesi" Whiteaves (not Trask) appears to be more nearly related to *Lytoceras traski* nov. than to *L. batesi* (Trask), although both are found in the middle Horsetown of the Cottonwood district.

"Ancyloceras remondi" Whiteaves (not Gabb) may be compared to *Shasticrioceras poniente* nov., described from the lower Horsetown (Barremian) beds in the Cottonwood district, California.

"Olcostephanus (Astieria)" deansi Whiteaves was described as coming from Skidegate Inlet (Graham Island ?). Stanton (1895) has mentioned a closely related species found on the Cold fork of Cottonwood Creek, associated with other species, all of which come within the limits of the Paskenta group.

More recently a considerable collection of Lower Cretaceous fossils, obtained in the near vicinity of Village Bay, Graham Island, not far from the Indian village of Skidegate, was collected by R. M. Kleinpell and E. W. Galliher and donated by them to the California Academy of Sciences. The locality is said to be 2 miles north of the village and was given the field number 77 in their report. Among the species collected at this locality the following may be noted:

Lytoceras argonautarum Anderson was described from middle Horsetown (lower Aptian) beds near Mitchell Creek, Shasta County, California. It is characteristic of the Argonaut zone described in this paper.

Desmoceras voyi Anderson was first found in middle Horsetown (lower Aptian) beds on Alderson Creek, 2 miles south of Ono, Shasta County. Five well preserved examples were obtained at Village Bay, Graham Island.

Aucella indigenalis nov. was obtained at Locality 77, 2 miles north of Skidegate village; ten good specimens were collected, one of which is figured (pl. 8, fig. 10). A similar species occurs in the Barr zone of the Horsetown group, about 6 miles south of Ono, Shasta County.

Aucella terebratuloides Lahusen was obtained at Locality 77; one of the three fairly well preserved examples collected is attached to a specimen of *Desmoceras voyi*, making a noteworthy association of species. *A. terebratuloides* has been found in the Horsetown group on McCarthy Creek, Tehama County, California.

The locality near Village Bay from which this collection came is within the area mapped by MacKenzie as the Yakoun formation, thus indicating a structural condition at this point that has escaped recognition.

From the foregoing notes it will be seen that strata as old as middle Horsetown (Bedoulian) occur on Graham Island, and, as indicated by one species, even older beds.

The group of strata represented by the foregoing list of species has not been described, and little is known as to its character or stratigraphic relations, nor has it been named. Its occurrence on Village Bay would suggest the name Village formation, which may be correlated with either the Barr zone or the Argonaut zone of the Horsetown group in the Cottonwood district of California.

FAUNAL CONTRASTS IN THE SHASTA SERIES

General Statement.—As reflected in the fossil invertebrates now known from the Shasta series, two distinct biotic areas are apparent in the Sacramento embayment—that of the northern Cottonwood drainage, Shasta County, and that crossed by Elder and McCarthy creeks, Tehama County. In view of their situation on the same border of the embayment and the short interval between them, these areas show some surprising faunal

contrasts. The interval between them is little more than 20 miles. In both, the stratigraphic sequence of the Shasta series is nearly complete, each containing the two major groups of strata of similar thickness. In fact the depositional sequences in the two areas seem to be parts of the same general body of sediment. It may be supposed, however, that the southern area contains Cretaceous strata somewhat older than the northern, and this may be true to a limited extent. But such a fact affords no explanation of the faunal contrasts which are evident, and which run almost entirely throughout the Shasta series in these areas.

In the district between Thomes and Elder creeks, the fauna of the older group, through a vertical range of 1800 feet, is dominated by *Aucella*, of which there are at least 11 distinct species, as determined by Pavlow. With them are found various species of cephalopods, including berriasellids, olcostephanids, and neocomitids, specifically different from any found in the northern district. Only a few species of ammonites are known to be common to the two areas in the lower group. Many of the cephalopods found at the south are confined to this area. Among belemnoids the case is somewhat different, and a number of species is common to both districts. The contrasts in faunas are illustrated by the total absence of *Aucella* in the lower group at the north. None have yet been found, although a few, and mostly different, species of *Aucella* have been found in the upper group at the north. Reference to the lists of species from the Paskenta group in the two areas will illustrate these facts.

Similar contrasts of faunas continue almost throughout the Horsetown group in the two districts. The abundant cephalopods in the Horsetown group in the Cottonwood district have few representatives in this group in Tehama County, although a few species are common to both districts. There is a general scarcity of ammonites in the Horsetown group south of the delta. The plant remains in the Paskenta group, as far as known, show similar contrasts, in that they are abundant south of the delta and comparatively rare to the north. On the contrary, the Horsetown group north of the delta contains much fossil wood, some leaves, cones, and nuts especially in the Hulen beds, but at the south these are not plentiful.

The causes of the faunal contrasts here described probably lay in the hydrological condition of the embayment already described, namely, the inflow of large volumes of fresh water laden with sediment from the land areas to the west, seasonally cooled, and having a southward current along the western side of the embayment; tidal currents bringing in marine water that followed the eastern shore northward and into the areas north of the delta; and lastly the influence of these currents upon the molluscan life entering the embayment from the sea, but in part coming from opposite directions along the littoral corridors of the time.

Sources of the Faunas.—Earlier writers have pointed out that the faunas

with which we are concerned represent migrations from opposite directions, and in part from antipodal regions of origin, from which they have found their ways into the embayments. The boreal character of the aucellan element in the fauna of the southern district was recognized by Hyatt, Smith, and Stanton. With this element, certain cephalopod genera scantily represented in the Cottonwood district may have come by the same route from the north during Paskenta (Valanginian) time. The nearest analogues of these aucellan species are found in Russia, and some of the associated cephalopods can be traced to the same source, or in the same direction, namely, the berriasellids, olcostephanids, and *Bochianites*.

As has been noted, the cephalopod faunas in the northern district, especially those of the Horsetown group, are largely if not wholly of southern or subtropical aspect. Their nearest relatives or allies are found in the Cretaceous areas of southwestern Asia (Australia, Cutch, and Caucasus Mountains), and they seem to have reached the eastern Pacific and this embayment by way of a southerly route, not yet fully understood, but which is perhaps explainable in terms of paleogeographic conditions of land and sea.

At first thought it has seemed surprising that the boreal fauna, represented by species of *Aucella*, are found almost wholly south of the delta area, whereas the subtropical faunas are so greatly developed in the Cottonwood district north of the delta. The varied cephalopod faunas of the Horsetown group in this area have been found very little represented outside of it. These faunas include many genera and species of *Phylloceras*, *Lytoceras*, *Crioceras*, *Ancyloceras*, *Parahoplites*, *Acanthoplites*, *Sonneratia*, *Cleoniceras*, *Beudanticeras*, *Desmoceras*, and *Puzosia*, described in the following pages. Their sources and migration routes must be sought in southern, rather than in northern, latitudes.

That the contrasted faunas did not mingle more freely in the intervening area is no doubt attributable to its deltaic character and to the dislike most of the molluscan types had for the freshened, sediment-laden waters of this area. This view does not wholly explain the presence of the boreal fauna south of the delta and that of the southern faunas on its northern flank. However, should the contrasted faunas prove to be not strictly contemporary, which seems unlikely, this would not invalidate the views here expressed but, in effect, might even support them. If we assume the existence of two or more inlets from the sea to the south of Klamathonia, and circulating currents within the embayment, the molluscan migrations from the north along the then existing littoral would enter the embayment at the first suitable gateway and from it would colonize the basin only insofar as conditions permitted. If they were able to tolerate cool, fresh and sometimes turbid water, they might travel northward along the west border of the embayment for a considerable distance, until conditions

became intolerable to them. On the other hand, migrations of southern origin following the littoral northward would enter the basin at a more southern gateway and would be carried northward by inflowing tidal currents, to enter whatever suitable places were open to them.

In this way the areas north and south of the delta could be colonized during any and every epoch of the period. Such currents, and such Mollusca as found it congenial, could also enter the Yolla Bolly basin, and during the time of its marine occupation they evidently did so, although the freshened condition of its water had a selective influence upon them. The water discharged from this basin would of course take the shortest way to the sea and thus follow the west border of the embayment southward.

All the known facts pertaining to this embayment tend to support the assumption of circulating currents within it during the whole of Cretaceous time.

DIASTROPHIC HISTORY

The crustal disturbances that have affected the Cretaceous troughs and basins of the Pacific Coast, although known mainly from local effects, are not regarded as of only local import. Some of them at least seem to have been felt in many latitudes along the coast between Alaska and Patagonia and through many degrees of longitude as well, probably reaching many parts of the Pacific basin. It may be that the succession of these disturbances began in pre-Cretaceous time, perhaps at the beginning of the Knoxville epoch, but a complete record of these events cannot be attempted here. In the deposits left in the several embayments in Oregon and California, especially in later Cretaceous time, there are many disconformities that indicate that during this period conditions of instability existed in and about these troughs. It is possible that this condition pertained essentially to the basins rather than to the areas and structures within the enclosing mountain areas, although both have participated in the readjustments. The movements recorded in these deposits may have been only local effects resulting from widely extended causes, although the denudation of neighboring land areas and the consequent loading of basin floors would necessitate repeated readjustments. Whatever the cause, it is now possible to recognize a succession of such events in the later Mesozoic deposits of the Pacific Coast, beginning with the opening of Knoxville time. The diastrophic records that pertain to the Cretaceous period itself began at the close of Knoxville time and may be summarized as follows:

(1) A post-Knoxville disturbance, regional in geographic spread, but differential in effects, producing local uplifts, withdrawal of the sea from many areas, and the shifting of strandlines in the troughs still occupied by the sea. The Joaquin embay-

ment seems to have suffered a partial withdrawal of the sea, whereas the withdrawal from the Sacramento embayment was less complete, and deposition of sediment continued locally almost uninterrupted.

(2) Mid-early Cretaceous movements, differential in their effects, followed by widespread subsidence in central California and along the Pacific Coast between Alaska and Mexico, if not also far to the south, seemed to have opened new gateways into the Great Valley embayments Their principal areas and also their lateral branches extending into the surrounding land were then flooded, in all of which the deposits of this early epoch were laid down. At many points on the borders of these embayments local conglomerates mark the points of stream entrance from the adjacent lands, indicating that the latter were not affected by subsidence.

(3) A mid-early Cretaceous uplift, differential in its effects, resulted in the withdrawal of the sea from many erstwhile flooded areas, including the Joaquin embayment, in part, the Yolla Bolly basin, and other areas in southwestern Oregon and farther to the north. In the still-flooded areas of the Sacramento embayment the strandlines were withdrawn to new positions, and new lines of stream conglomerates were formed far within the limits of earlier expansions. Such conglomerates mark the base of the Horsetown group and the boundary of the sea about the delta area already partly developed. In some places on the borders of the embayment there was subsidence, as at Ono (Cottonwood district), where Horsetown deposits rest directly upon basement rocks, showing that the uplift was differential with local results. The absence of early Horsetown deposits from many Coast Range areas in California, Oregon, and from places farther north, may be taken as evidence of uplift and withdrawal of the sea from these areas at or about the close of Valanginian time. How far this uplift was felt along the Pacific border is not known, but faunas of early Horsetown age have not been reported from any areas north of the Great Valley, except perhaps about Queen Charlotte Islands and neighboring points on the mainland. Later Horsetown (Aptian to upper Albian) deposits are known in the Joaquin embayment, in southern Oregon, and farther north, and in Alaska. From facts now known in parts of California and in Oregon, it is clear that the uplifts at the beginning of Horsetown time were not followed immediately by subsidence at all points; the subsidence was gradual with continually expanding transgressions by the sea.

(4) This epoch of subsidence, in which Horsetown deposits were laid down, was brought to a close only in late Albian time by diastrophic events which entailed a new cycle of sedimentation and of faunal changes. Disturbances were widespread, but their effects varied greatly in different areas of the coastal regions. Along most of the west border of the Sacramento embayment, the early Chico strandlines, as shown by fossil-bearing conglomerates, were shifted to varying positions on the preceding Horsetown sequence, thus giving evidence of movements within the trough of unequal degree; in other areas on the borders of this embayment, in the Joaquin embayment, and in the embayments of southern Oregon (Umpqua and Rogue River valleys), fossiliferous lower Chico conglomerates rest directly upon pre-Cretaceous formations, giving evidence of subsidence and transgression. Such facts seem to be recorded also in many areas in Alaska and in other countries bordering the Pacific.

(5) The disturbances that initiated the Chico deposition were followed by a prolonged period of subsidence in many areas in which deposits of this series were laid down. This condition of subsidence began in late Albian time and continued throughout Senonian time, although not without many interruptions. In the Sacramento embayment transgression began at the north on its western border and from there extended gradually southward and eastward; in the Joaquin embayment subsidence began in local areas (Mount Diablo, Quinto Creek, and Waltham Creek)

and extended thence southward, but with many interruptions which cannot now be completely followed.

The long period of time occupied by the deposition of the Chico series, and its many intervals of interruption, and of faunal changes, can hardly be attempted at the present time, although it was filled with events and incidents of historical interest equal to any mentioned in the preceding paragraphs.

CORRELATIONS

General Statement.—In the widely scattered areas of Lower Cretaceous deposits in California and southwestern Oregon, beds that seem capable of correlation with those in the standard column in the Sacramento Valley have already been considered, but other areas in more remote parts of the coast have been recorded, about which little has been known. There are few places on the Pacific border in which the entire Lower Cretaceous sequence, as exposed here, has been found. Parts of such series only are more widely scattered, but faunal criteria for correlation are lacking in many cases.

Paskenta Group.—For the most part, beds referable to the Paskenta group only have been found beyond the limits of the Sacramento Valley. These beds have wide distribution, but they usually contain faunas capable of recognition as such. They have been described from many areas between southern California and Alaska. Less frequently beds have been described that seem comparable to the Horsetown group, as developed in the Sacramento Valley (Shasta and Tehama counties). In southwestern Oregon (Douglas and Curry counties), deposits referable to the Shasta series are extensively developed and resemble it in lithology, and in part in faunas, but not in stratigraphic thickness.

The "Myrtle formation" in its type district south of Roseburg, especially near Riddle, is said to have a thickness of about 6000 feet. It includes beds that are referable to the Paskenta group, upon which rest other beds that may represent the Horsetown, but their thickness is not very great. The fauna of the lower beds includes some elements not yet known in the Shasta series of California, although neither is completely known.

No Cretaceous deposits have been recorded from the Willamette Valley.

In the State of Washington evidences of Lower Cretaceous deposits only have been found in scattered areas. In British Columbia, as at Harrison Lake, Tatlayoco Lake, and on some of its islands (Vancouver, San Juan, and Admiralty) equivalents of the Paskenta group, or parts of it, have been found. Such beds may also occur on Queen Charlotte Islands, but to the writer's knowledge only the upper portion of the Shasta series (Horsetown) has been shown to occur there, as near Skidegate Inlet.

In Alaska, Lower Cretaceous deposits are widely distributed and, ac-

cording to Martin, they occur in many, if not all, of the larger coastal valleys. Concerning these deposits, Martin (1926, p. 266) says, in part:

> "A wide-spread marine transgression in early Cretaceous time carried the sea over most, if not all, of the area which is now Alaska."

Although the faunas of the early Cretaceous deposits known in Alaska have been only partly described, there are many references in the literature to *Aucella*-bearing beds, including species belonging to the group of *Aucella crassicollis* Keyserling, sometimes accompanied by other forms (*Belemnites*, *Perisphinctes*, and *Olcostephanus*), or by plant remains thought to be Lower Cretaceous. Not all the *Aucella*-bearing rocks described from Alaska are of Cretaceous age; some are older and are known to be Jurassic.

Although Martin makes no mention of Knoxville beds and gives little evidence that strata referable to this series occur there, yet, in referring to fossil collections made from certain shales near Port Moller, he quotes Stanton (Martin, 1926, p. 291) as including in some lots "forms related to *Aucella piochii*" (lots 5571, 5572 (part), 5576).

Whether this and other references to the occurrences of *Aucella piochi* Gabb in the Mesozoic strata in Alaska may be taken as evidence of the Knoxville (late Jurassic) series there is not known; the species may be found to range lower. However, it appears that most, if not all, of the references to *Aucella crassicollis* Keyserling may be taken as evidence of Lower Cretaceous (Valanginian) strata. According to Martin's account, such Lower Cretaceous deposits occur at widely separated places in Alaska (Herendeen Bay, Cooks Inlet, Chitina Valley, Admiralty Island, lower Yukon, Rampart-Tanana region, Koyukuk Valley, Coville Valley, and Innoko and Iditarod valleys).

Regarding some of the "Lower Cretaceous" deposits reported from Alaska the records are not altogether clear; the lists of fossils from the "Kennicott formation" in the Chitina Valley region given by Martin (1926, p. 336–339) indicate ages ranging from upper Jurassic to upper Albian or later. It may be possible later to divide the succession represented in these lists into a number of distinct units.

As seen in this and other literature of Alaska most areas of Lower Cretaceous deposits there lie in, or about, the larger valleys, or in the coastal areas of Alaska. From these facts it may be inferred that Martin's "marine transgression" at this epoch may have been largely confined to its coastal borders and the larger pre-Cretaceous valleys, just as they were in California and Oregon, and probably in British Columbia, and that between these valleys were older mountain ranges from which the Cretaceous sediments were derived. It may also be noted from these

accounts that the Lower Cretaceous deposits containing *Aucella crassicollis* and associated fossils rest in some places upon Upper Jurassic (?) strata with *Aucella* cf. *piochi*, and in other places upon Triassic, or even upon Paleozoic formations (Chitina Valley, Admiralty Island, Rampart-Tanana district, and upper Yukon region). These facts may be taken as evidence that in Alaska, as in California and Oregon, the Lower Cretaceous sequence began with a "marine transgression," following a widespread subsidence that led the sea into many already-formed troughs, ancestral to existing valleys. As far as known, the faunas most characteristic of the Lower Cretaceous in Alaska are similar to those of the Paskanta group in the Shasta series in California, and, without evidence to the contrary, they may be assumed to be contemporary with them. Concerning the forms of *Aucella* found in the early Cretaceous of the Matanuska region Stanton (Martin, 1926, p. 313) says, in part:

> "This is the same large species which was identified as *A. crassicollis* Keyserling in Mendenhall's collection from Bubb Creek. While this Alaskan species may not belong to *A. crassicollis*, as restricted by the Russian paleontologists, who recognize a very large number of species of *Aucella*, it does belong to a group of forms which is most abundant in the Lower Cretaceous, and is therefore suggestive of Cretaceous age, . . ."

Horsetown Group.—Beds that may be correlated with the upper part of the Horsetown group seem to have been found in scattered localities in Alaska (Alaskan Peninsula, Chitina Valley, and lower Yukon), but, if we may judge from the summary accounts and especially the lists of marine invertebrates given by Martin, the evidence is not abundant and not always very convincing. An examination of the fossil lists from the various sections of the Lower Cretaceous in Alaska has failed to reveal any species characteristic of the lower part (Hauterivian or Barremian) of the Horsetown group. None of the larger ammonoids found in the Cottonwood beds have been recorded, and in many places the absence of species representing upper Horsetown beds leads to the suspicion that they are absent. In this respect the Lower Cretaceous in Alaska resembles that in California in that slow subsidence led to transgressive overlaps throughout Cretaceous time. It has already been shown that south of the Great Valley of California no faunal evidence of Horsetown strata has been recorded.

Mexico and Texas.—The Lower Cretaceous deposits in Mexico and Texas have little resemblance to the Shasta series in California and Oregon, either faunally, lithologically, or in stratigraphic thickness. For the region of Mazapil and Concepción, south-central Mexico, Burckhardt (1930) gives a general column (Valanginian to Cenomanian) totaling 3380 feet; for northern Chihuahua, Böse (1910b) gives a maximum for Middle and Lower Cretaceous of 8700 feet, of which less than half is older than Albian. Kellum (1936) gives a summary of the Cretaceous

deposits found in the Sierra de Parras, including estimates of thickness made by Imlay, in which the Lower Cretaceous sequence attains a maximum of 5782 and 5620 feet. At Bisbee, Arizona, the sequence is said to have a thickness of 4700 feet, including conglomerates, sandstones, and shales. Estimates of the thickness of the Lower Cretaceous in Texas, made by Adkins, shows a maximum of 4647 feet. In all these areas, and in many others, limestones predominate, often forming nearly the entire series. Lithologically the columns of the Lower Cretaceous in Mexico and Texas contrast greatly with contemporary deposits in the detrital Shasta series in the Sacramento Valley which attain a thickness of 13,000 to 27,000 feet. In Oregon corresponding beds have a thickness in some areas of nearly 6000 feet, and in others apparently more.

The faunas of the Comanche series in Mexico and Texas show equally great contrasts with those of the Shasta series, except that each series contains a few genera of wide geographical range. The Lower Cretaceous faunas in Mexico and Texas, and contemporary deposits in the northern Andes (Colombia and Peru), pertain to the Tethyan-Mediterranean province, whereas the faunas of the Shasta series are for the most part of Indo-Pacific affinities, having closer relations with those of Australia and southwest Asia (Cutch and Caucasus mountains). The lithological and faunal contrasts in the Shasta and Comanche series have been noted by Stanton (1897) and by others, but, in view of their bearing upon paleogeographical problems, they should be further emphasized. Only a generic resemblance can be shown in the faunas of the older portions of the two series. Both contain species of *Olcostephanus* (*Astieria*), *Polyptychites*, *Spiticeras*, *Pulchellia*, *Berriasella*, *Neocomites*, *Thurmannia*, *Bochianites*, and perhaps others. But such analogues do not reach specific resemblances and do not often show close relationships.

In Barremian horizons there is a single species of *Pulchellia* known in the Shasta; in Aptian strata there are species of *Parahoplites* in both series; and in Albian horizons there are forms of *Douvilleiceras*, *Oxytropidoceras*, and others, but the species are never identical and do not indicate direct connections between Atlantic and Pacific waters during any epoch of early Cretaceous time. The absence from the Shasta series of many genera and families of cephalopods characteristic of the Comanchean faunas has been noted by Stanton. No examples of *Leopoldia* or of *Acanthodiscus* have been recorded from the older beds of the Shasta series, nor have hoplitids of the lineage of *Dufrenoya* been found in the Barremian of the Shasta. Echinoids are rare in the Shasta series, and there are few forms of Ostreidae, caprinids, or monopleurids, all of which are abundant in the Mexican and north Andean Lower Cretaceous. On the other hand, the Tethyan Lower Cretaceous contains none of the heavy-shelled forms of *Aucella* or of the large species of *Inoceramus* common in

the Shasta series. Among cephalopods the Antillean Lower Cretaceous contains few, if any, of the large lytoceratids, crioceratids, ancyloceratids (*Tropaeum*, *Shastoceras*, and *Hemibaculites*), or phylloceratids, such as characterize the Horsetown group of the Shasta series. Contrasts of this character could easily be further extended, continuing through the Lower Cretaceous in the two provinces, but they seem unnecessary at present.

These contrasts seem to show little, if any, faunal exchange between the Atlantic and Pacific provinces in early or Middle Cretaceous time Any resemblances that exist between them can be more easily accounted for in some other way.

Argentina and Chile.—The faunal contrasts, long known in the Shasta and Comanche series of North America, reflect the distinctness of the Indo-Pacific from the Tethyan-Atlantic provinces during late Mesozoic periods. No such contrasts have been pointed out between the faunas of the Shasta series and those in the Lower Cretaceous of Chile and western Argentina. Both are regarded as having Indo-Pacific relations which ally them to some extent at least. Kitchin (1926) traces faunal relationships from Argentina eastward to the Indo-Pacific basin, but without referring to the important West Coast faunas represented in the Shasta series and in contemporary deposits farther north—partly for the reason that they have not been known. He says, in part:

> "The deposits of Lower Cretaceous age in Bolivia, Chile, and Argentina republic, as well known, have paleontological characteristics in common with the Lower Cretaceous beds of South African and Tanganyika Territory. Related faunas of like age are also present in Madagascar, in Cutch, near Coconada (east coast of India), in Hazara (western Himalays), and in New Caledonia."

Had Kitchin known the American West Coast faunas, as here illustrated, he could have continued these analogies farther eastward.

European Sections.—When the sedimentary succession of the Shasta series in California and Oregon is compared with those of Europe for purposes of correlation their great stratigraphical and lithological contrasts at once appear. The total thickness of contemporary deposits in western Europe and England is estimated at less than one-fifth of that found in California, so that their respective subdivisions cannot easily be compared. In some measure the same statement applies also to Oregon and to other parts of the Pacific Coast. According to estimates gathered from authentic sources (Geikie, 1893) the Cretaceous system in England attains a maximum thickness of less than 4200 feet, nearly half of which represents the Wealden, largely included in the Infra-Valanginian. Overlying this in southeastern England are sediments of Neocomian to Senonian ages, inclusive, having a thickness of 2128 feet. Neither these aggregates, their subdivisions, chronological units, nor the stratigraphic ratios of the latter compare well with those of the California sections. As the

Lower Cretaceous deposits of western Europe and the American West Coast belong to different faunal provinces, direct correlations between them are not often easy to make, but indirect correlations between parts of their general columns are sometimes possible, and to some extent the faunal order in the Lower Cretaceous in England and California is somewhat parallel throughout. Some of the faunal assemblages described from the section at Speeton, England, and from western Europe seem to have counterparts in the Lower Cretaceous of California, but there is not always a close agreement in the order of their occurrence in the two provinces.

For the present, therefore, the correlations made here with the standard chronological divisions in the Lower Cretaceous of Europe are offered with some reserve and are subject to alterations as the faunas become better known and their faunal zoning becomes more complete.

Southwestern Asia.—From the study of the collections so far made, it appears that, in part at least, relations between the faunal assemblages in the Lower Cretaceous of California and southwestern Asia and Australia are closer than between those of California and western Europe. Although geographically remote, the agreements in faunas and faunal succession (Hauterivian to Aptian) in the Caucasus region and in the the Sacramento embayment seem surprising but are none the less understandable.

The Lower Cretaceous faunas of New Caledonia are not yet sufficiently well known to be compared with those of the American West Coast, and the same may also be said concerning those of Japan.

FAUNAL RELATIONS

General Statement.—When one considers the varied character of the Lower Cretaceous faunas and the faunal succession herein described, it seems evident that the areas and environmental conditions of the known troughs and embayments of the West Coast are too limited to have been the cradles of their origin and development and that one must look elsewhere for centers of dispersal from which migrations could have reached these regions.

It is not yet clear to what other regions one should look for the sources of their several elements, nor do the conditions of sea and land about the Pacific basin seem capable of providing sources or the necessary routes of travel for all of them. Their biotic relations and possible sources are suggested by the character of some of the elements themselves, although they point to remote regions and require speculative hypotheses to meet the demands of migration thither. However, in the absence of better guiding facts, these suggestions may be considered as acceptable until better ones have been found. If the history of the Pacific and its environs

were better known, our problem might be simplified, but on the other hand the facts herein offered should aid in the study of this history itself. It may be possible that during late Mesozoic time the eastern borders of the Pacific basin were very different from those of the present and that they may have afforded suitable environmental conditions for the development of immigrant faunas and for their migrations to other shores, but of this little can now be said. No important Jurassic faunas are known on the West Coast from which the faunas of the Cretaceous, particularly their varied cephalopods, could have been derived. With regard to the aucellan elements, similar difficulties are apparent. Although the boreal aspect of both the late Jurassic (Knoxville) and the early Cretaceous species of *Aucella* in the California and Oregon embayments is well known, the types found in the two series are as distinct here as in Russia, where the analogues of both are well known and occur in the same order. One may accept for both a line of exchange through Arctic America, Alaska, and British Columbia. Although a part of the Lower Cretaceous ammonoids of the Oregon and California troughs have generic allies in the upper Knoxville (Tithonian) deposits, including *Phylloceras*, *Lytoceras*, *Berriasella*, and *Spiliceras*, they are specifically too unlike to warrant a belief of lineal descent, and certainly the more characteristic ammonoids of the Paskenta group cannot be traced to local Tithonian sources. Most of them have closer allies in more distant regions. The belemnoids of the two series are of different types, as they are in other regions, and the same is true for other classes of invertebrates. Some of the hoplitids (*Neocomites* and *Thurmannia*), olcostephanids, and crioceratids may have come with *Aucella* from northern Europe and Arctic America. In general, however, the cephalopods of the Paskenta group in Oregon and California seem to have come from sources within the environs of the greater Pacific basin. An unknown but considerable number seems to have come from northern latitudes, but many more must have reached these embayments from more southern sources, or by way of them.

In contrast with the few groups of cephalopods found in the older Cretaceous is the great number in the Horsetown group, as known in the Cottonwood district. The more characteristic genera found in these beds (Hauterivian to Aptian) are not known from any other West Coast areas, north or south of the Great Valley trough. For the great majority of them, sources must be sought in subtropical regions, from which the routes of migration are now obscured, probably owing to the tectonic history of the eastern border of the Pacific basin. Close relationships are to be seen in many of the Horsetown ammonoids and contemporary cephalopods in southwestern Asia (Spiti, Caucasus, Cutch, and Australia), particularly in the Barremian and Aptian genera of the Parahoplitidae, lytoceratids, ancyloceratids, and various others. Some of the

Parahoplitidae are almost, if not entirely identical. Among the ancyloceratids may be mentioned *Tropaeum* and *Australiceras*. Such analogous species are found also in the early Albian of the California embayments. These facts can be understood only on the assumption of suitable routes of exchange across the Pacific basin during early Cretaceous time, possibly beginning in the earliest epochs of the period, but at all events existing during later times.

Such routes of travel should lie far to the south rather than to the north. The absence of most, if not all, of the older Horsetown ammonoids from Alaskan and Japanese Cretaceous deposits seems to harmonize with this view, although such evidence is somewhat negative and not conclusive.

Many known facts concerning the Pacific basin and the terrestrial and marine faunas, past and present, upon its borders support the hypothesis of a land bridge across the south Pacific during late Mesozoic times. To what extent Burckhardt's (1900b) evidences of an ancient Pacific continent would support this hypothesis is not known. Gregory (1922) and others have supposed that direct communication between Atlantic and Pacific waters existed in the Panama region during later Cretaceous time, but convincing evidence of this has not been given. There is little in common, however, between the early Cretaceous faunas of the northern Andes and Mexico on the one hand, which are typically Mediterranean, and the contemporary California faunas, which are Indo-Pacific in character. This fact seems to be true also for the later Cretaceous faunas in these regions.

The existence of a trans-Pacific land bridge in Mesozoic time has been suggested by various writers in the past, but the subject has been more recently revived and enriched by much new evidence that has been summarized by Gregory (1930) and others, supporting the assumption. The topic has also been recently discussed by Schuchert (1930) who seems to have been not entirely satisfied with the evidence offered by von Huene.

The possibility of such a bridge, or bridges, has been given support by data supplied by Chubb (1934) who has studied the distribution and character of the continental rocks in the general areas of the South Pacific and given his interpretation of the same.

We may be justified in accepting the evidence and deductions of these writers and in believing that during early Cretaceous time land connections between southwestern Asia and western South America had existed, in effect at least, dividing the area of the present Pacific into two more or less equal parts. This bridge is thought to have extended across the Pacific, mainly south of the Equator, reaching South America in the latitudes of northern Chile and southern Peru. For the migration of some forms of Mollusca, including cephalopods, complete land connection may not have been essential, if we assume the existence of ocean currents

along the littoral zones westward in these latitudes. Land animals would of course require some epochs of complete land connection for their migrations, but for marine animals it could be different. These may have followed either the northern or southern borders of a land bridge between the Asiatic and American continents. Whatever extensions of such land may have existed toward the north is not known, but one may suppose that a broad zone of land extended from Peru to Mexico, or even to southern California, forming an effective barrier far west of the present Isthmus, between the north Indo-Pacific and the Comanchean sea of Texas, Mexico, and the Northern Andes. This isthmian land would explain the faunal contrasts between the Shastan and Comanchean faunas already discussed, and at the same time suggests routes of molluscan migrations between opposite shores of the north Indo-Pacific ocean. Favorable currents traversing the northern littoral of such land bridges during early and middle Cretaceous times might bring the marine faunas of southwestern Asiatic regions and of intervening stations into the American West Coast embayments in which they are now found.

Diverse Sources.—In accord with the foregoing views, it may be suggested that some elements in the early Cretaceous molluscan faunas of the Sacramento embayment (e.g., Berriasellids) may have had progenitors in the late Jurassic (Tithonian) stocks near at hand; other types (olcostephanids, neocomitids) now found mingled with *Aucella* may have come into the embayment with them from northern European sources by way of Arctic America; others (*Spiticeras*, hoplitids, and crioceratids) may have come from southern or far western (Asiatic) sources by way of a south Pacific corridor.

At the opening of Horsetown (Hauterivian) time a new order of life began in the Great Valley trough, partly as the result of immigrations from without, but in part from more local stocks. However, migrations continued to arrive at intervals until the close of Horsetown time. In the early part of this epoch generic types (*Neocraspedites*, *Lytoceras*, and *Hoplocrioceras*) arose partly from local stocks. At later epochs during Barremian time came *Ancyloceras*, *Acrioceras*, and *Shastlicrioceras*, followed in early Aptian time by new lytoceratids, *Parahoplitoides*, *Nautilus*, and forms of *Acroteuthis*. In early Gargasian time came *Australiceras*, *Tropaeum*, *Shastoceras*, *Hemibaculites*, and new forms of *Phylloceras*, soon followed by *Parahoplites*, *Cheloniceras*, and hamitids, and later by *Acanthoplites*, *Douvilleiceras*, *Sonneratia*, *Cleoniceras*, and *Beudanticeras*. In brief, new assemblages continued to appear, bringing into the embayment at successive intervals lineages of cephalopods not here before, although no doubt many were autochthonous. Meanwhile, many of the earlier stocks and their descendants disappeared. Almost all the inhabitants of Valanginian time had vanished before Barremian time or were

replaced by races with which they could not compete. Probably not all left fossil remains; some may have been shell-less. Evidences of battle are numerous and indicate that shelled forms (e.g., *Ancyloceras* and crioceratids) were vanquished, and their races disappeared soon after arrival.

A critical epoch in the order of cephalopod life in the Great Valley trough was at the beginning of Horsetown time, as recorded in the faunas of the early Cottonwood beds and in the succession that followed. These successive faunas are dominated by types that are also dominant in nearly the same order in the Lower Cretaceous of southwestern Asia, as also in other regions.

To what event in the geological history of the Pacific basin, or of the world, could this abrupt change be attributed? Whatever the answer, it is clear that important immigrations into this trough followed a quite definite orogeny that seems to have affected in varying degrees the entire Pacific Coast from California to Alaska, and perhaps far beyond. Whether parallel facts could be recognized in Mexico and the Andean countries cannot now be stated.

In some areas in Oregon, and apparently in California, Horsetown deposits did not immediately follow those of Paskenta time. This fact could be taken as evidence of local uplift and of withdrawal of the sea from such areas. That the sea was withdrawn from certain areas of the trough while still occupying others has already been shown. Far within the outer limits of its expansion during Paskenta time are found thick beds of conglomerate, marking roughly the strandlines of early Horsetown time, particularly in the Cottonwood drainage areas. In other areas no such conglomerates are found, and in some there are evidences of subsidence and of overlap of Horsetown deposits upon pre-Cretaceous formations. No lower Horsetown deposits have been reported from the Diablo Range south of Quinto Creek, nor farther to the south, although they may have been removed from many places or otherwise lost from view.

Although lower Horsetown deposits are indicated by fossils on Queen Charlotte Islands, few have been reported from Alaskan areas, even where beds of Paskenta age are known.

Without evidence to the contrary we may infer that the crustal disturbances that ended Paskenta time and resulted in the conditions described for the early Horsetown epoch in California were not local, although they produced local effects not everywhere alike. Such differential results have been described for some of the Andean countries and for Mexico and the Rocky Mountains and seem to have affected other regions. Burckhardt (1930) in describing these differential movements in Mexico, which correspond to the uplift that closed the Paskenta epoch in California, says in part:

"In marked contrast with this expansion of the sea there is shown in northern Mexico a regressive phase following Valanginian deposition."

A similar retreat of the sea is described from Texas and Arizona, and, as suggested, also in Alaska.

It may be carrying the rights of inference too far to suggest that the south Pacific land bridge may have been incomplete or only partially effective in the earlier part of Cretaceous time and that not until Hauterivian time were connections between Asia and America sufficiently complete to permit migrations hither. Nevertheless, such suggestions are inherent in the subject and arise spontaneously in the study of the faunas, their origin, relations, and succession in lower, middle, and later Horsetown deposits in the Great Valley embayments of California.

By what other route could the families, the genera, and even near-specific analogues have reached the American coast during the epochs of their dominance in those distant regions (Caucasus, Cutch, and Australia)?

Disturbances similar to those at the beginning of Horsetown deposition brought this epoch to a close in late Albian time, resulting in the spreading of Chico sediments unconformably upon those of the Shasta and older terrains. The biotic results of this disturbance at the close of the Shasta period cannot be given here, but it may be added that the faunal changes effected at this time in California and Oregon are comparable to those already described for the beginning of the Shasta period and at the beginning of Horsetown time; new and unfamiliar stocks were brought into the embayments in late Albian time from apparently remote sources; these facts seem most readily explainable by the supposition of widespread earth movements at this point of geologic history.

The tectonic record of the Chico period is replete with incidents, as is also the records of arrivals of new assemblages of invertebrate life.

GENERAL SUMMARY

The Cretaceous deposits of California and Oregon are probably the most complete and representative of this period that occur on the Pacific Coast and they contain a succession of marine invertebrate faunas unequalled in any other known area on the Pacific border. Yet they have been but little explored, and therefore little has been known concerning them, either of the circumstances of their accumulation, their stratigraphical features, or their faunal character of order. Although large areas of Cretaceous deposits are known in other troughs in the Coast Ranges of these States, and farther north, the thickest, most fossiliferous, and in many ways the most important, are those found in the Great Valley trough of California. Within this trough the maximum thickness of the succession (Shasta and Chico series) is not less than 50,000 feet. For the most part the Cretaceous troughs in California and Oregon, as in other parts of the Coast, are inherited from Jurassic time, or perhaps in

part from early Mesozoic time, with only minor changes through successive periods.

The land areas bordering these troughs on the west were in part peninsular, and in part mountainous islands, between which waterways gave ingress from the open sea into partially land-locked, trough-like basins or embayments. One of the most important of the outpost land areas was that embracing the present Klamath Mountain complex, here described under the name Klamathonia, but others of less importance existed to the south.

The geographical extent and physiographic aspect of these land areas can only be inferred from the distribution, character, thickness, and attitude of the marine deposits now found within the enclosed troughs. In the Great Valley trough of California these deposits lie chiefly along its western border—that is, along the eastern flanks of older mountain areas limiting the trough on the west. In such positions these deposits outcrop in a somewhat discontinuous zone for a total distance of nearly 400 miles, extending to the northwest and southeast.

Within the trough of the Great Valley, two distinct embayments, here known as the Sacramento and the Joaquin embayments, have been recognized. The geological records in these embayments have not been parallel throughout the period. In the former the stratigraphical thickness of the deposits is much greater, and deposition covered most of the chronological stages known in other parts of the world, beginning in Berriasian time and continuing into Senonian, with only partial interruptions. Later stages are but little represented in this embayment, although in places they appear in its southern part. In this embayment the Cretaceous deposits attain an aggregate thickness of at least 36,000 feet, of which the Shasta series alone reaches a maximum of nearly 27,000 feet. This series is divided into two principal groups—the Paskenta and the Horsetown—attaining a thickness of 11,300 and 15,700 feet respectively. Evidences of disconformity are now recognized between these groups.

Unconformably upon the Shasta series rests the Chico series, with a maximum thickness of 9000 feet, and in some places it overlaps the older series and rests directly upon the basement rocks. This series of strata includes the oldest part of the California Upper Cretaceous, its deposition beginning in late Albian time and continuing in the Sacramento embayment to near the close of Senonian time.

In the northern part of the Sacramento embayment lower Cretaceous deposits constitute a typical delta, filling a large triangular area in which it spreads fan-like from an apex at the west, which marks the point of river discharge from the mountainous background within the limits of Klamathonia. Within its areal limits this delta, including the southward drift of its sediments north of Thomes Creek, contains approximately 4900 cubic miles of Cretaceous sediment, not including any portion that

may have been lost during, or subsequent to, its period of deposition. This sediment is almost wholly detrital and has been derived from a commensurate land area, which was then occupied by a river system of like proportions, and which carried a volume of water corresponding to the work accomplished. Such an area of basin-like form, adjacent to the delta, is now occupied by the Trinity River system, which in Cretaceous time had a possible drainage area of 5300 square miles, including a large part of the present Klamath River drainage. The larger part of this area comes within the limits of the Yolla Bolly basin, whose drainage direction has been reversed since Cretaceous time. This reversal of direction was due partly to faulting and uplift on its eastern side, and partly to downwarping on its western border. Into this intermontane basin, marine water entered from the east and received sediments from the surrounding mountains, remnants of which, containing marine, partly marine, and fresh-water Mollusca, still remain intact but widely scattered within the basin.

It would require the removal of nearly one mile of surface material from the entire drainage area here described to have supplied the sediment found within the delta area in the Sacramento embayment. The accumulation of detritus constituting this delta could have been built up only under conditions of prolonged subsidence in the embayment, of which the vertical measure would equal an abysmal depth scarcely credible, considering the present restricted breadth of the trough; its breadth may have once been greater.

Much of the coarser sediment brought into this area by the river was dropped near its discharge point, whereas the finer sediment was carried farther from it. The current from the river would be southward along the west border of the trough, and this would automatically induce tidal currents northward along its eastern border, producing segregated areas of purely marine and partly freshened water on opposite sides of the embayment and the setting up of rotating currents within it.

The axial part of the delta lies along the Shasta-Tehama County line, dividing it into two unequal districts to the north and to the south of this line. These districts would present in Cretaceous time considerable contrasts in ecological conditions, which would react upon the faunas and their development throughout the entire period.

At the north is the North Cottonwood district of restricted area, and at the south the more extensive district crossed by the South fork, Redbank, Elder, McCarthy, and Thomes creeks in Tehama County. Both districts are rich in marine Mollusca, which constitute parallel and nearly contemporary faunal successions which, when biotically compared, show surprising contrasts. For these we must suppose either different sources of origin, or different ecological conditions of life and development, or both.

In the southern district the lowest Cretaceous fauna is dominated by

robust, thick-shelled species of *Aucella*, comparable to, if not specifically identical with, contemporary boreal and Russian faunas. These are accompanied by a number of cephalopods, some of which are boreal, although some are not. Species of *Aucella* range through the lower group of sediments in the district south of the delta, some appearing even as late as Albian time (uppermost Horsetown).

In the North Cottonwood district no species of *Aucella* have been found in contemporary beds, or in any strata below the Aptian, where a few specimens have been collected. In this district the fauna of the Paskenta group (Valanginian), although not large, consists of cephalopod species, only a few of which occur in the southern district, and with them are species not found south of the delta. A few diagnostic species are common to both districts, including both cephalopods and pelecypods.

The faunas of the Horsetown group in the two districts show a greater number of common or analogous species, although at the north cephalopods occur in greater number and variety, many of which are not found at the south. In the North Cottonwood district is found a succession of ammonoid faunas ranging from lower Hauterivian to middle Albian; only a few of these are found south of the delta, as is true of other classes.

Nearly all the ammonoid stocks in the Horsetown group are of southern, or subtropical, aspect and have their nearest analogues in southwest Asia (Himalayas, Caucasus, Cutch, and Australia); few of them have been found farther north along the Pacific Coast, although our knowledge is yet incomplete. Only a few of the many cephalopods in the Horsetown are known to have near analogues in Argentina or other South American countries. In view of their number found in southwestern Asia and Australia, this fact is surprising.

In the lowest part of the Horsetown group both north and south of the delta, there are heavy beds of conglomerate and other coarse detritus, as if at the beginning of this epoch (Hauterivian) an uplift of the mountain areas to the west had shifted the strandlines eastward within the trough and at the same time had stimulated the erosive and transporting energy of the streams. It was at this juncture that a new cycle began in the faunal sequence, which brought into the embayment new and unfamiliar types and families of cephalopods, many of them of Asiatic aspect. This disturbance at the beginning of Horsetown time seems to have been felt along the Pacific border from Mexico to Alaska, although its effects were differential, producing elevation in some areas more than in others. This movement seems capable of correlation with similar phenomena described for central Mexico and for some Andean countries far to the south. Possibly at this epoch the land and water conditions in south Pacific regions permitted migrations or faunal exchanges between Asiatic and American littoral embayments.

For the later part of Cretaceous time three major events, of two phases

each, seem to be recorded in the stratigraphical sequence and in the faunas found in the Sacramento embayment, the results of which can be only briefly sketched here. One of these events was initiated at the beginning of Chico (late Albian) time; its second phase covered the subsidence that followed, during which the earliest deposits of this series began to accumulate. A second disturbance, differential in effects, was initiated in early Senonian (Coniacian) time, and this stage was followed by a long-continued subsidence and the deposition of a sequence of Upper Cretaceous strata which was locally interrupted in middle Senonian time. This sequence of strata is of small areal extent on the western border of the Sacramento embayment but is of greater spread on its eastern border and of still greater extent in the Joaquin embayment in which partly parallel events are recorded, but continued to a later epoch.

In the Joaquin embayment, extending south from Mount Diablo, Lower Cretaceous deposits are known in a number of districts on the east flank of the Diablo Range (Mount Diablo, Quinto Creek, Waltham Creek, and Devils Den), but they are not continuous, and their areas are not large; neither do the strata attain in all places a constant thickness.

Near Mount Diablo the thickness of the Lower Cretaceous does not exceed 5000 feet; near Quinto Creek it is much less; in the Devils Den district it may be 12,000 feet. Near Coalinga and in Waltham Creek Valley it is thought to attain to 15,000 feet, but this figure represents the maximum thickness in the Diablo Range. One may suppose that the normal, or original, thickness of the Lower Cretaceous in the Joaquin embayment had been from 12,000 to 15,000 feet and explain the discrepancies in the sections in part by faulting and in part as a result of overlap of the Chico series upon the older groups of the Cretaceous succession.

In the southern, as in the northern, embayment three diastrophic events are recorded in the upper Cretaceous sections. One is at the base of the Chico series; one is at the beginning of Senonian (Coniacian) time; and another is later, probably in Late Senonian time (late Campanian).

The Cretaceous sections in the Joaquin embayment differ from those in the Sacramento embayment in the almost complete absence of Horsetown beds and in the much greater development of Upper Cretaceous, especially during the closing epochs of the period.

In the southern coastal areas of California, including Lower California, and also in southwestern Oregon, scattered occurrences and incomplete data indicate that the major diastrophic and depositional events, at least, described in the preceding paragraphs were not wholly local but are traceable to the north and south far beyond the limits of the Great Valley trough and its embayments.

PART II. PALEONTOLOGY

DESCRIPTION OF SPECIES

GENERAL STATEMENT

The following descriptions by the writer recognize and adopt the results of earlier workers as far as possible without dwelling upon their errors.

Many of the descriptions are based upon older holotypes whenever obtainable, although in some cases this has not seemed necessary. Search has been made in the field for topotypes of species described from the Shasta series, if their holotypes have not been available, and for the horizons represented by them. From the study of the field and its sequence of faunas it is now possible to state more precisely the horizons, if not the localities, from which the original types were obtained. In the descriptions of species given by Gabb (1869b) there is often little information as to their stratigraphic position, and this fact has been a source of much uncertainty, and in some cases confusion. In the present work this confusion is in part removed, although much remains to be added by later explorations and more careful collecting and zoning.

There are few collections at hand from the Cretaceous of Europe and other regions for comparative study and the descriptions of the fossil materials now available. For this reason it has been necessary to rely largely upon published figures and descriptions found in the literature of various countries. In some cases this method has been fairly satisfactory; in other cases much doubt has been felt. In many cases, however, the sequence of faunas in the Shasta series and their correlations have afforded some confidence and have aided somewhat in the determination of genera and species.

In the matter of taxonomy it has been the writer's purpose to be conservative, rather than over progressive, and for this reason he has been reluctant to adopt many innovations that have seemed to be only theoretical, or experimental, and incapable of satisfactory proof. On the other hand, in a few cases, after long and seemingly exhaustive search for appropriate genera in which to include certain forms, it has seemed to be necessary to propose new generic groups for their reception.

In the matter of families it has been found that the usage of Spath (1924), or of Whitehouse (1926) has seemed to meet most of the requirements of the cephalopod groups found in the Shasta series, and as far as possible these have been adopted.

It may be that in some cases errors have resulted, and in fact they could scarcely be avoided, but if this work were delayed until these and other difficulties were removed, it would not soon be done. However, the remoteness of this province from that of Europe and other regions from which Lower Cretaceous faunas have been described affords some measure of relief from the exactions imposed upon students working under the shadow of older institutions. Whatever shortcomings may result from these and other circumstances, it is believed that there are many students of Mesozoic paleontology in this and other countries who will welcome the new and significant matter contained in this contribution, even though in the view of some it may seem defective. For such students this work has been done.

ECHINODERMATA

Echinoderm remains are not abundant in the Pacific Coast Cretaceous, although in both California and Oregon they have been found sparingly in the lowest stratigraphic group of the Shasta series, and also in the lower part of the Chico series and in its later beds. Stanton (1895, p. 31) has mentioned the discovery of spines and fragments of the test of *Cidaris*, and joints of the column of *Pentacrinus*, on the Shelton ranch, north of Paskenta, Tehama County, and the latter genus also at Stephenson's on the Cold fork of Cottonwood Creek, Tehama County.

Clark later described these forms as far as their fragmentary condition permitted; accounts of them are here given. At both localities these fossils occur in the Paskenta group of the Shasta series, not far from its local base, and incidentally indicate near-shore conditions of the strata from which they came. Evidences connected with their occurrence and their associates confirm this view. Stanton (1895, p. 22) also mentions the finding of remains of *Pentacrinus* in beds of nearly the same age near Riddle, Oregon.

CIDARIDAE Gray

Cidaris Leske

Cidaris tehamaensis Clark

Cidaris tehamaensis CLARK, U. S. Geol. Surv., Mon. 54, 1915, p. 44, pl. 9, fig. 1; Shelton's ranch, 5 miles north of Paskenta, Tehama County.—KEW, Univ. Calif. Publ. Geol., vol. 12, 1920, p. 54, pl. 3, fig. 1; locality as above.

This species is described from a single spine, as follows: "Test unknown. Spines large and club-shaped, with rows of granules extending from neck to point of spine." Length 30 mm.; width in thickest part, 12 mm.

PENTACRINIDAE Gray (emend.)

Pentacrinus Blumenbach

Pentacrinus tehamaensis Clark

Pentacrinus tehamaensis CLARK, U. S. Geol. Surv., Mon. 54, 1915, p. 35, pl. 6, fig. 1; Shelton's ranch, 5 miles north of Paskenta, Tehama County.

Clark describes the species as follows: "Column composed of small medium sized pentagonal joints, some with and some without sharp reentering angles. Crenulated ridges pentoid. Column perforated by a small canal." Diameter of joint, 3 to 6 mm.; thickness of joint, .5 to 1 mm.

This species is among the oldest echinoderms found in the Cretaceous of California.

MOLLUSCOIDEA

BRACHIOPODA Duméril

RHYNCHONELLIDAE Fischer

Rhynchonella whitneyi Gabb

Terebratella Whitneyi GABB, Paleont. Calif., vol. 2, 1869, p. 35, pl. 12, figs. 62, 62a; "Miocene," Napa County, California.

Rhynchonella Whitneyi GABB, Paleont. Calif., vol. 2, 1869, p. 204, pl. 34, figs. 105, 105a, 105b; Shasta group (Cretaceous), Colusa County—STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 32, pl. 1, figs. 5–10; near Wilbur Springs, Colusa County, California.

Stanton's account and excellent illustrations of this species are quite adequate. Its horizon is, however, one of primary importance in the stratigraphy of this and other West Coast Cretaceous areas. Stanton states that at its type locality it is accompanied by *Pecten complexicosta*, *Modiola major*, *Lucina colusaensis*, and other species. All the species mentioned characterize the limestones found here and at many other localities in California and Oregon. As *Aucella crassa*, *A. inflata*, *A. crassicollis*, and other Lower Cretaceous species are found in the sandy shales both east and west of these limestones at the type locality, and at other places, there should be no doubt that the entire fauna of these limestones is of Cretaceous age. Similar evidences are found in other localities in which this species occurs. In fact these limestones seem to represent only a local facies in the Lower Cretaceous (Paskenta group) in the Coast Ranges of California and Oregon. The presence of Knoxville strata near Wilbur Springs, beneath the lowest beds of the Paskenta group, is evident, but here and at many other places the unconformable relations of the two series is equally clear.

TEREBRATELLIDAE King (emend. Beecher).

Terebratella d'Orbigny

Terebratella californica STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 33, pl. 1, figs. 12, 13: near Stephenson's on Cold fork of Cottonwood Creek, Tehama County.

The figures and description of this species by Stanton need no emendment. The species was thought by Stanton to belong in "the upper part of the Knoxville beds," which in this paper constitutes the Paskenta group of the Shasta series. The field position and stratigraphic relations, as well as the species associated with the holo-

type as given by Stanton (1895, p. 14), show that the horizon is not lower than Lower Cretaceous (Valanginian). Among the associated species contained in his list are *Aucella crassicollis, Pecten californicus, Cyprina occidentalis* Whiteaves, and *Acroteuthis impressa* (Gabb). The locality is at the base of the Paskenta group; none of the 18 species of this list are found in the Knoxville series (Tithonian) as here restricted.

Terebratella densiconis (Anderson)

(Plate 1, figures 6, 7)

Rhynchonella densiconis ANDERSON, Calif. Acad. Sci., Pr., 3d ser., vol. 2, 1902, p. 72, pl. 7, figs. 157, 158; Horsetown and Texas Springs, Shasta County.

Shell of medium size, diameter 11 to 12 mm.; trigonal, gibbous, when full grown, the greatest thickness being near the middle; lateral margins straight, meeting at an angle of about 90 degrees at the beak; anterior margin broadly rounded; dorsal valve more convex than the ventral, inflated; ventral valve flattened, rising in front in a pronounced sinus; anterior part of each valve bears angular or rounded plications which disappear near the central part of the shell; surfaces of both valves bear fine striations, best seen on the posterior half of the shell. The sinus on the ventral valve bears three or four plications, denticulated on the margin; margin of dorsal valve denticulated, the longer plications pointed and tooth-like when seen from the front; beaks not prominent; deltidium small; width of shell greater than the length. This shell resembles the northern forms, *"Rhynchonella" gnathophora* Meek, and *"R." maudensis* Whiteaves, although the latter appears to be relatively broader in front.

This species is not uncommon at Horsetown and Texas Springs, Shasta County, in the highest beds of the Horsetown group. Its horizon should be upper Albian.

Terebratella whiteana (Anderson)

(Plate 1, figures 4, 5)

Rhynchonella whiteana ANDERSON, Calif. Acad. Sci. Pr., 3d ser., vol. 2, 1902, p. 72, pl. 7, figs. 160, 161; Horsetown and Texas Springs, Shasta County, California.

This shell differs from the preceding mainly in its finer sculpture and less prominent plications and marginal denticulations. The sinus on the ventral valve possesses about nine or ten plications and as many marginal denticles. It occurs with the preceding, and is probably confined to the same horizon.

Terebratella ovula Anderson, n. sp.

(Plate 9, figures 17, 18)

Shell small, ovate, longer than broad, convex, smooth and without ornamentation; almost equivalve, the ventral valve extending a little behind the margin of the dorsal valve; length of the ventral valve of the holotype, 20 mm.; width of ventral valve, 16 mm.; thickness, 11 mm.; front marked by only a faint median sinus in the dorsal valve; surface of the shell smooth and silky.

The holotype (Calif. Acad. Sci. type Coll.) was found in the Neptune zone on the east branch of Hulen Creek, locality 1659 (Calif. Acad. Sci.), associated with *Lytoceras neptunianum, Douvilleiceras mammillatum*, var., *Beudanticeras breweri*, and many other species characteristic of the upper Horsetown (middle Albian) beds of this district. Three good examples of the species were found here.

TEREBRATULIDAE Gray

Terebratula Müller

Terebratula hannana Anderson, n. sp.

(Plate 9, figures 14, 15)

Shell of medium size, circular in outline, regularly lenticular, convexity moderate; borders below the beak forming an angle of near 110 degrees; front nearly circular; length of dorsal valve (incomplete) in holotype, 22 mm.; length of ventral valve of paratype, 38 mm.; sculpture of dorsal valve in holotype consisting only of concentric undulations; sculpture of ventral valve almost without ornament, smooth. The holotype (Calif. Acad. Sci. type Coll.) consists of a fairly well preserved dorsal valve. The paratype (Calif. Acad. Sci. type Coll.) is a well preserved ventral valve. Both were found by G. D. Hanna on McCarthy Creek, near the crossing of the Paskenta-Lowry road, southern Tehama County. They were associated with a species of *Cheloniceras*, near if not in the zone of *Neocraspedites signalis* nov., and not far above the zone of *Acrotsuthis onoensis* and *Inoceramus colonicus* nov., the two latter representing a Hauterivian horizon in this locality and in the Cottonwood district. It appears, therefore, that its horizon may be regarded as representing a middle Horsetown (Barremian) horizon.

Terebratula durrelli Anderson, n. sp.

(Plate 9, figure 16)

Shell of moderate size, subcircular in outline, irregularly lenticular, owing to broad plications extending from the beak forward; the ventral valve has a broad rounded ridge extending from the beak toward the front; the dorsal valve has a broad crescent-shaped, transverse ridge, in front of which is a broad median sinus; surface of shell silky, showing only faint concentric lines; length of ventral valve (incomplete), 25 mm.; length of dorsal valve, 23 mm.; total width of shell, 28 mm. The holotype (Calif. Acad. Sci, type Coll.) was found by Cordell Durrell on Fiddler Creek, 10 miles south of Ono, Shasta County, associated with *Shasticrioceras poniente* nov. not far beneath the zone containing *Cheloniceras hindsi* and *Acrotsuthis shastensis*. Its horizon is regarded as middle Horsetown (Barremian), although it may be somewhat lower.

MOLLUSCA

PELECYPODA

Nucula gabbi Stanton

Nucula gabbi STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 51, pl. 6, figs. 11, 12; upper part of "Knoxville beds," about 3 miles south of Lowry's, Tehama County.

Stanton's holotype of this species is comparatively small (19 mm. in length), of which he gives excellent figures and description. He compares the species with *N. solitaria* Gabb, from the "Chico" of Texas Flat, near Folsom, and also with *Nucula "solitaria"* Whiteaves, from the probably Jurassic of Moresby Island, but at present the relationships seem improbable. Stanton mentions several smaller specimens of this species collected from a lower horizon in the limestone lens 3 miles northwest of Paskenta, but this appears to be a distinct species.

The field position and the stratigraphic relations of the type locality of this

species show that it belongs in the Paskenta group of the Shasta series, and it is very doubtful that it has been found in any other beds.

LEDIDAE Adams

Leda Schumacher

Leda glabra Stanton

Leda glabra STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 53, pl. 6, fig. 18; near Stephenson's, Cold fork of Cottonwood Creek, Tehama County.

The locality, field relations, and stratigraphic position of the strata from which the holotype was obtained show clearly that it was found in the basal beds of the Paskenta group, immediately above its basal conglomerate which forms Stephenson's Peak, on the south side of the creek. It was found accompanied by 14 other species belonging in the lower part of the Paskenta group.

PARALLELIDONTIDAE Dall

Nemodon Conrad, 1869

Genotype *Nemodon "eufalensis"* Conrad

In the belief that Conrad's species (1869, p. 97, pl. 9, fig. 18), the genotype of *Nemodon*, is distinct from *Arca* (*Macrodon*) *eufalensis* Gabb, it was renamed *Nemodon conradi* by Johnson (1905, p. 9). It is said to have come from the Upper Cretaceous of New Jersey. The subject has been reviewed by Stewart (1930, p. 67) whose emendment of Conrad's description aids greatly in the concept of *Nemodon*, leaving it clear that under this generic name should be included many of the West Coast species related to *Nemodon breweriana* (Gabb). Whiteaves (1879, p. 163) attached this generic name to two distinct species, under the impression, however, that they were synonymous. In discussing *Nemodon vancouverensis* Meek, he placed *N. breweriana* (Gabb) as a probable equivalent of the former, and this suggestion has since been accepted by others.

The most important feature upon which the genus seems to have been founded is in the character, form, and position of the hinge teeth, as is well shown by Stewart, although he has proposed a different designation for Gabb's species. From the careful review of *Nemodon* given by Stewart, it does not appear that this genus can be properly placed under *Parallelodon* Meek, although the genera are closely allied.

Nemodon breweriana (Gabb)

(Plate 2, figures 3, 4)

Arca Breweriana GABB, Paleont. Calif., vol. 1, 1864, p. 193, pl. 25, fig. 11; Cottonwood Creek, Shasta County; vol. 2, 1869, p. 248; Chico Group, Cottonwood Creek, Shasta County.

Nemodon (*Arca*) *breweriana*, WARING, Calif. Acad. Sci., Pr., 4th ser., vol. 7, 1917, p. 57, pl. 7, fig. 56; Calabasas quadrangle—NELSON, Univ. Calif. Publ. Geol., vol. 5, 1925, p. 406.

Parallelodon (*Nanonavis*) *breweriana*, STEWART, Phila. Acad. Nat. Sci., Special Publ. no. 3, 1930, p. 69, pl. 3, fig. 1.

Gabb's species is not uncommon in the Cretaceous of California and Oregon. It is very abundant in the lower beds of the Chico series on the Cottonwood Creek, Shasta County, from which horizon Gabb's holotype probably came. The specimen figured in this paper came from the same zone, and may be taken as a topotype. However, the species being one of the few that survived from earlier epochs in the

Sacramento embayment, it is not confined to the Chico series. It has been found in the lower beds of the Horsetown group at Ono, and in the upper, and perhaps the lower beds of the Paskenta group in the Cottonwood district. It is congeneric with *Nemodon vancouverensis* Meek, which belongs to a higher horizon, but their identity can scarcely be maintained.

Nemodon (?) *tehamaensis* (Stanton)

Arca tehamaensis STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 50, pl. 6, figure 8; Shelton's ranch, 5 miles north of Paskenta, Tehama County.

The holotype of this species is small, and Stanton regarded it as being "probably an immature individual," stating also that he had "not seen the hinge," and that "the general form of the shell makes it probable that it belongs to the subgenus *Nemodon*." On the Shelton ranch it occurs with *Aucella crassicollis*, "*Olcostephanus*" *mutabilis* Stanton, and other species of the Paskenta group in the Shasta series. As the stratigraphic position of this species on the Shelton ranch appears to be near that of Locality 113 (Calif. Acad. Sci.) in the Cottonwood district and near the top of the Paskenta group in both, Stanton's holotype may well be the young of a species of *Nemodon* found at Locality 113, and at other places in the Cottonwood district, as at Locality 1656 (Calif. Acad. Sci.) on Duncan Creek.

Nemodon (?) *textrina* (Stanton)

Arca textrina STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 50, pl. 6, figs. 6, 7; near Stephenson's on the Cold fork of Cottonwood Creek, Tehama County.

This is a small species of distinctive form and sculpture, of which Stanton says, in part:

"surface marked by distinct, closely arranged lines of growth and by similar, slightly larger radiating lines, which are not at all conspicuous to the unaided eye."

Although Stanton compared this form with "*Gramatodon*" *inornatus* Whiteaves, he states that "it should probably be referred to the subgenus *Nemodon*." Its form and sculpture indicate that it does not belong to either of the preceding species, although it probably is a *Nemodon*. Its occurrence in Stanton's list (1895, p. 14) with *Aucella crassicollis*, "*Belemnites*" *impressa*, and *Lima multilineata* shows that its position is in the upper part of the Paskenta group. A similar form, probably the same species, was found on the North fork of Cottonwood Creek, a mile or more south of the diversion dam above Ono. Its position here is about 600 feet beneath the zone of *Thurmannia jupiter*—that is, below the Hamlin-Broad zone of the Paskenta group.

ARCIDAE Dall

Glycymeris Da Costa

Glycymeris ovatus (Stanton)

Pectunculus (?) *ovatus* STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 51, pl. 6, figs. 9, 10; near Stephenson's on Cold fork of Cottonwood Creek, Tehama County.

The hinge characters of this shell as well as its general form and radial surface markings, as given by Stanton, should leave little doubt as to its generic position. It is the oldest form of this genus recorded from the Cretaceous of California, and it is specifically unlike any other form of the genus yet found in these beds.

The species is included in a list (Stanton, 1895, p. 14) of 15 other forms specifically

named by Stanton, which also includes *Aucella crassicollis* and *"Belemnites" impressa* Gabb. Its stratigraphic position and relations have already been discussed, and its association with the last-named species establishes its Paskenta age.

PINNIDAE Meek

Pinna Linnaeus

Pinna pontica Anderson, n. sp.

(Plate 2, figure 2)

Shell small, rather stout, slightly curved, tapering to an acuminate point; section of shell rhomboidal, dorsal and ventral borders thin; sides angulated, but showing a distinctly raised ridge; basal margin rounded, divided at the median line of the side; surface marked by nearly parallel longitudinal ribs on the dorsal part of the shell, separated by wider interspaces; ventral part of the shell bearing two longitudinal ribs parallel to the median ridge, below which are oblique undulations arising at the ventral border and extending upward and toward the base, meeting the ribs beneath the median line; apical angle about 33 degrees. The surface ornamentation of this species is not unlike that of *Pinna calamitoides* Shumard, as figured by Whiteaves, but in size and in the apical angle there is much difference.

The holotype (Calif. Acad. Sci. type Coll.) was obtained at Locality 1353 (Calif. Acad. Sci.) near the bridge on the North fork of Cottonwood Creek, in the Ono zone of the Horsetown group. It affords the following measurements: total length, 68 mm.; greatest width, 35 mm.; thickness at base, 26 mm.

The holotype was found associated with *Inoceramus colonicus, Acroteuthis kernensis*, and *Neocraspedites aguila* nov., all of which characterize the zone. This appears to be the oldest known species of *Pinna* in the Cretaceous of the West Coast capable of description, although Stanton (1895, p. 49, 92) mentions a small form, possibly an immature specimen, found on the Shelton ranch, in beds here referred to the Paskenta group, and therefore lower in the series.

Pinna equivillana Anderson, n. sp.

(Plate 2, figure 1)

Shell of medium size, elongate, tapering to a near point, moderately thick, borders not straight; cross section rhomboidal, margin acute, sides slightly curved; valves divided near the middle by an angulated ridge (124 degrees), extending from apex to base; dorsal side of valves narrower than the ventral; borders of shell slightly bent, dorsal concavely, ventral convexly; surface of dorsal part marked by six or seven narrow, subparallel ribs, separated by broader rounded interspaces; ventral portion showing eight or nine such ribs and interspaces; these are crossed obliquely by a few faint undulations; apical angle about 33 degrees.

The holotype (Calif. Acad. Sci. type Coll.) was found at Locality 1668 (Calif. Acad. Sci.), in the Perrin zone, where it was associated with *Acanthoplites perrini, Sonneratia rogersi*, and *Phylloceras theresae* nov. It has the following dimensions: total length, 144 mm.; greatest width, 70 mm.; greatest thickness, 40 mm.

This species has been obtained at three separate localities on Hulen Creek—Localities 152, 1659, and 1668 (Calif. Acad. Sci.). It differs from all the species known from the later Cretaceous of the West Coast chiefly in its apical angle, its cross section, and in the manner of its surface ornamentation. The stratigraphical range of the species is apparently confined to the Hulen beds, although it may be found to range lower.

INOCERAMIDAE Heinz

In this family Heinz (1932, p. 5, 6) includes the great majority of the sub-families and new genera he has proposed for the *Inocerami* of earlier usage. However, as his proposed classification, and most of his past studies, have had to do only with Upper Cretaceous forms (Cenomanian and later), their application to the older Cretaceous forms remains somewhat uncertain, and accordingly no attempt is made at present to adopt either his methods or his taxonomy.

Inoceramus Sowerby

Inoceramus ovatus Stanton

(Plate 4, figure 9)

Inoceramus ovatus STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 47, pl. 4, fig. 15; South fork of Elder Creek, Tehama County.

In general form and surface markings this shell is not unlike *I. ellioti* Gabb, and represents a low position in the Paskenta group. Its sub-triangular outline, sharp beak, and short hinge line are among its distinguishing features, and in these it apparently conforms to the type of *I. ellioti*. Stanton regarded it as belonging in the "upper Knoxville beds," which in this memoir constitutes the Paskenta group of the Shasta series. The species has recently been found in the Paskenta group on the Middle fork of Cottonwood Creek, where it was associated with *Hoplocrioceras remondi* (Gabb), a form more frequently found in the Paskenta group, but occurring also in the basal Horsetown.

Inoceramus ellioti Gabb

(Plate 7, figure 1)

Inoceramus ellioti GABB, Paleont. Calif., vol. 2, 1869, p. 193, pl. 31, fig. 90; Alcatraz Island, Bay of San Francisco—STEWART, Phila. Acad. Sci., Spec. Publ. no. 3, 1930, p. 106, pl. 2, fig. 2; later figure of the holotype.

The holotype of this species is in the Museum of the Academy of Natural Sciences of Philadelphia and has been re-figured by Stewart. It consists of an incomplete cast of both valves, somewhat distorted by an oblique fault, as shown in Stewart's figure. The effect of this fault has been to shorten and also broaden its original form, and the apex of the beak is missing, so that Gabb's figure is misleading as to form. At the time Gabb's figure was made the holotype was in little better condition. The holotype is accompanied by a second fragment of a right valve, possibly representing the same species, and both may have been used in Gabb's attempted restoration. The outline of his figure could hardly have been made from the holotype, but as he himself says, it was made "from a cast (or mold) in sandstone." Gabb afterward obtained from the same place "casts of this and several other bivalves," one of which is described in another place as *Lucina alcatrazis* nov. The holotype of *I. ellioti* has the following dimensions: length of left valve (incomplete), 85 mm.; greatest width, 68 mm.; thickness of both valves, 30 mm. A drawing made from the holotype (Pl. 7, fig. 1) is more accurate. In form and size, if not in sculpture, it resembles mature examples of *Inoceramus ovatus* Stanton, and belongs to its group, and also its horizon. It seems to be also closely related to *I. quatsinoensis* Whiteaves.

Inoceramus ovatoides Anderson, n. sp.

(Plate 6, figure 2)

Shell large, somewhat robust, elongated, subtriangular, inequivalve, hinge short, anterior margin straight, left valve having a strongly incurved, spiral beak; anterior margin deeply rounded; right valve flattened, longer than broad, beak nearly terminal, acuminate; surface of cast nearly smooth, or marked only by faint concentric undulations; inner layers of shell smooth, often pearl-bearing; prismatic layers thick, brittle, not often preserved; outer surface not well preserved; form somewhat variable. This shell often attains a length of 15 to 17 cm., and incomplete shells have been found which had an original length of 20 cm.; the width is usually about half the length. In general form and markings the shell recalls that of *I. ovatus* Stanton, but it is much larger and less clearly marked by concentric undulations, and is relatively narrower. It is abundant in the Mitchell zone in the Bald Hills, Shasta County, where it is usually accompanied by *Ancyloceras ajax*, *A. durrelli*, and *Acroteuthis onoensis* nov. It marks the Barremian and lower Hauterivian strata in the Cottonwood district, and its horizon is a little higher than that of *I. ovatus*.

The holotype (Calif. Acad. Sci. type Coll.) was obtained at Locality 1347 (Calif. Acad. Sci.) and measures as follows: length, 160 mm.; greatest width, 95 mm.; greatest thickness of left valve, 30 mm.

Near the bridge at Ono, a somewhat similar but smaller species is found associated with *Neocrospedites aguila*, *Phylloceras occidentale*, and a large form of *Lytoceras*, in strata regarded as lower Hauterivian.

Inoceramus colonicus Anderson, n. sp.

(Plate 4, figures 10, 11, 12; Plate 5, figure 1)

Shell of moderate size, narrow, elongated, with thick shell, and very unequal valves; left valve with a strongly incurved beak; right valve with a narrow terminal beak; shell brittle, and rarely found complete. The shell of this species resembles that of *I. ovatoides* in general form and surface markings, but is narrower relative to length, the left valve has a longer and more incurved beak, and its stratigraphic range is apparently greater. It is abundant at Locality 1353 (Calif. Acad. Sci.), where it is accompanied by *Neocrospedites aguila* and many other invertebrate species. Its name is taken from its apparent habit of living in close colonies. A single example of the species was found on McCarthy Creek, Tehama County, about 1000 feet west of the Paskenta—Lowry road, associated with *Hibolites cigarroides*, *Acroteuthis onoensis*, and *A. shastensis* nov.

The holotype (Calif. Acad. Sci. type Coll.) and the paratype were obtained at Locality 1651 (Calif. Acad. Sci.), a mile west of the Murphy ranch house, and a mile south of Roaring River, Shasta County, where it was associated with *Shastlerioceras poniente*, *Acrioceras starrkingi*, *Pseudocrioceras stentor*, and *Acroteuthis shastensis*, in strata regarded as Barremian. The holotype measures as follows: length, 110 mm.; width, 50 mm.; thickness of left valve, 20 mm. The paratype is somewhat smaller.

Inoceramus vallejoensis Anderson, n. sp.

(Plate 6, figure 1)

Shell very large, subquadrate in outline, broad, beaks sub-terminal; hinge line short; surface marked by only concentric undulations 2 to 4 cm. apart; valves flattened, not much inflated; shell brittle, not well preserved. A single example of

this species was found at Napa Junction, Napa County, in 1912, in the excavation made for "cement rock." In length this shell was 10 inches or more; in width about 7 inches; in thickness 2 inches. It was found with *Lima multilineata* Stanton, *Modiolus onoensis* nov., and the borings of Pholads. A single example of the same type and form, but somewhat smaller, was found in 1908 by Josiah Owen near Alma, Santa Clara County. The strata in both cases belong to the Paskenta group of the Shasta series, as determined by other molluscan species. These examples recall the statement found in the San Francisco folio (Lawson, U. S. Geol. Surv., 1914, p. 8) that fragments of a large *Inoceramus* and a small *Pecten* had been found in Strawberry Canyon in the Berkeley Hills, in strata that seem to belong to the same group. Mention of a species of "*Hoplites*" found near the same place is also made, and serves to support the age determination of the locality.

Pteriidae Meek

Avicula Bruguière

Avicula (Oxytoma) whiteavesi Stanton

Avicula (Oxytoma) whiteavesi Stanton, U. S. Geol. Surv., Bull. 133, 1895, p. 38, pl. 4, fig. 1; Shelton's ranch, 5 miles north of Paskenta, Tehama County.

Stanton compares this species with a shell found on Maude Island, one of the Queen Charlotte Islands group. Stanton's holotype was found in beds cropping out on the Shelton ranch, associated with *Aucella crassicollis*, "*Olcostephanus*" *mutabilis*, and other Paskenta species. A similar species has also been found in the basal beds of the Horsetown group near Ono. Lower Cretaceous strata have not been reported on Maude Island before, and for this reason Stanton's comparison is the more important. A considerable list of Lower Cretaceous species found about Skidegate Inlet is given in another part of this memoir.

MacKenzie (1916, p. 46–47) has given a list of species, including this, from Maude Island, which Stanton regarded as of Jurassic age, including it in the Maude formation.

Myalinidae Frech

Aucella Keyserling 1848

In an excellent review of the genus *Aucella* Stanton (1895, p. 41) states its circumpolar distribution thus:

"It is found over a large part of Russia, in Siberia, Nova Zembla, Spitzbergen, on the Island of Andoe on the coast of Norway, Kuhn Island on the coast of Greenland, in Alaska, British Columbia, including Queen Charlotte and Vancouver Islands, and the west coast of the United States as far south as San Luis Obispo County, California (about latitude 35°)."

Within its geographical range the genus occurs in both Jurassic and Lower Cretaceous deposits, and locally forms the dominant faunal element in parts of each sequence.

As these Aucellan elements are related to those of other regions, their occurrence in the Knoxville and Shasta series in California becomes important, not only as an aid in correlation, but as showing the routes of migration and the spread of the genus.

In the Shasta series, with few exceptions, they are confined to the Paskenta group. Most of the forms found in these beds are robust, thick-shelled species of the general character of *A. crassicollis* Keyserling, although this species is somewhat

rare. In his discussion of the types included by him under this name Stanton (1895, p. 45) says, in part:

"This description is meant to include all the robust varieties of *Aucella* that are characteristic of the upper part of the Knoxville beds in California, ranging through perhaps 1500 to 2000 feet of strata."

An attempt has recently been made to discredit the generic name *Aucella*, and to replace it by "*Buchia*," a name proposed by Rouillier in 1835. Whatever claim may now be made by anyone for the validity of "*Buchia*" upon the basis of priority, the fact is evident that most specialists, since Keyserling's time, have accepted the name *Aucella*, as defined by him, and this name has now, after more than 80 years of use, become so well established in the literature that no rule should be invoked to replace it. It would seem that the question had been sufficiently settled by Pompeckj (1901) but for those who may still be unconvinced, it may be recalled that Rouillier gave neither figure, description, nor any characterization of the species upon which he proposed to found the name "*Buchia*," but merely submitted to his society an example of a shell which he believed to be "*Avicula mosquensis*" Buch. Whether this shell was properly identified by him, we have no means of knowing. For this reason the name "*Buchia*," as remarked by Pompeckj, "did not meet with approval, as opposed to the name *Aucella* and its better characterization provided by Graf Keyserling for the new genus."

In the Lower Cretaceous deposits of Russia many forms of *Aucella* have been distinguished by specific names given by Keyserling (1843–1846), Lahusen (1888) and Pompeckj (1901), a general review of which has been given by A. P. Pavlow (1907). In this review of the succession of *Aucellae* found in the Upper Jurassic and Lower Cretaceous of Russia, and in contemporary beds in California, and with the aid of fossils obtained by him from this state, Pavlow was able to show marked parallelism in the stratigraphic occurrences of species common to both regions, and also many analogous forms. Others have since been discovered. Had Pavlow been able to obtain complete suites of *Aucella* from the Knoxville and Shasta series in California, this parallelism would probably have been extended farther. In addition to the more robust forms found in the Shasta serica, a few smaller species have been found, but none can be identified with species characteristic of the Knoxville series. Some difficulty is often found in identifying the immature shells of closely related species, but less is found in the separation of adult shells, and in this fact they follow the rule of many other genera.

The stratigraphical occurrence of the several forms of *Aucella* found in the Paskenta group is about as follows, although there are some overlaps:

Upper third—zone of *Dichotomites—Aucella crassicollis* Keyserling, *A. crassa* Pavlow, *A. terebratuloides* Lahusen;

Middle third—zone of *Neocomites* and *Berriasella—Aucella piriformis* Lahusen, *A. keyserlingi* Lahusen, *A. nuciformis* Pavlow;

Lower third—zone of *Phylloceras* cf. *Knoxvillense—Aucella solida* Lahusen, *A. uncitoides* Pavlow, *A. inflata* Toula, *A. lahuseni* Pavlow, and *A. nuciformis* Pavlow, the last occurring in two distinct zones, although not abundant in either.

It is not known whether this succession will be found in all sections, but at present it appears to maintain throughout the districts south of the delta.

The occurrence of *Aucella piochi* Gabb, or some related species, in the lower part of the Shasta series has been claimed by some, but this claim should be accepted with reserve. It may be based upon a misinterpretation of young forms of other species—*e.g.*, *A. lahuseni* Pavlow, or of the strata containing it, or both.

Not all species of *Aucella* found in the Paskenta group, and in overlying beds, can be described at this time, but a few of the more common forms are included in the following account; in this much reliance has been placed upon the work of Pavlow and other Russian paleontologists. However, no species contained in these accounts seems to have been derived from forms of *Aucella* found in the underlying Knoxville series, although this view of the subject should not be considered final. The *Aucellae* found in the Paskenta group seem to be more closely related to Russian types from beds that are probably contemporary with this group. From this viewpoint it seems more probable that their appearance in California and Oregon was due to migrations, or immigrations from north-European sources.

Aucella crassicollis Keyserling

(Plate 8, figures 1, 2)

Aucella crassicollis KEYSERLING, *Reise in das Petschora-Land*, 1846, p. 300, pl. 16, figs. 9–12.

Aucella Piochii GABB (in part), Paleont. Calif., vol. 2, 1869, p. 194, pl. 32, fig. 92a only; probably from western Colusa County (not *A. piochii* GABB, vol. 1, 1864, p. 187, pl. 25, fig. 173; north side of Mount Diablo).

Aucella crassicollis Keyserling, var. *gracilis* Lahusen, STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 45, pl. 5, figs. 10, 11; Paskenta group, Tehama County—PAVLOW, Soc. Imper. Natur. Moscou, Nouv. Mem. T. 17, 1907, p. 62.

"Buchia" crassicollis, STEWART (in part), Phila. Acad. Nat. Sci., Spec. Publ. no. 3, 1930, pp. 112–114.

This species is rather rare in the Paskenta group in California and Oregon. As many of the allied forms found in these deposits were included under this name by earlier writers, most of their references indicate other species, rather than this.

The species (*s.s.*) is found occasionally at different levels in the Paskenta group, but it occurs more frequently 1500 to 2000 feet above the base, in the zone of *Dichotomites mutabilis* (Stanton). Most examples of the species so far obtained are of the variety figured by Stanton (1895, Pl. 5, figs. 10, 11). This form is plentiful on the Wilcox ranch, 5 miles north of Paskenta, where it is associated with forms of *Berriasella*, *Bochianites paskentaensis* nov., and two or more forms of *Dichotomites*.

Examples of the species are in the collections of the Academy of Sciences which were collected by H. W. Fairbanks and the writer in 1894, about 7 miles east of Cayucos, San Luis Obispo County, where they have since been found associated with *A. crassa* and *A. lahuseni*. They are not known to occur in any part of the Knoxville series (upper Jurassic) or in any beds later than Paskenta.

Aucella crassa Pavlow

(Plate 8, figure 7)

Aucella Piochii GABB (in part), Paleont. Calif., vol. 2, 1869, p. 194, pl. 32, figs. 92, 92b only; probably from western Colusa County, near Wilbur Springs.

Aucella concentrica var. WHITE, U. S. Geol. Surv., Bull. 4, 1884, p. 14, pl. 6, figs. 9, 10; "Fossil point," Port Möller, Alaska.

Aucella (ventricose left valve) WHITE, U. S. Geol. Surv., Mon. 13, 1888, p. 232, pl. 4, figs. 16, 17; near Knoxville, California.

Aucella crassicollis, STANTON (in part), U. S. Geol. Surv., Bull. 133, 1895, p. 45–47, pl. 6, figs. 1, 2 (copied from Gabb).

Aucella crassa PAVLOW, Soc. Imper. Nat. Moscou, Nouv. Mem. T. 17, 1907, p. 69; species figured by GABB, Paleont. Calif., vol. 2, 1869, pl. 32, figs. 92, 92b, taken as the holotype.

"Buchia" crassa STEWART, Phila. Acad. Nat. Sci., Spec. Publ., no. 3, 1930, p. 112–113, pl. 2, fig. 4; "lectotype," (*A. crassa* Pavlow, refigured); Colusa County, California.

This is probably the most abundant species of *Aucella* found in the Paskenta group in its type district; it occurs throughout the lower division of this group. The holotype was found by Stewart in the collections of the Academy of Natural Sciences of Philadelphia and was designated by him as the "lectotype," although Pavlow (1907) had already taken it as the holotype of the species. This form is abundant 1½ miles northeast of Wilbur Springs, Colusa County; it has also been found 1200 feet northeast of Knoxville, Napa County. It is found more abundantly in the type district of the Paskenta group about 1500 to 2000 feet above its base, as on the Wilcox ranch, 5 miles north of Paskenta.

Aucella terebratuloides Lahusen

Aucella concentrica var. WHITE, U. S. Geol. Surv., Bull. 4, 1884, p. 13, pl. 6, figs. 2, 3, 4, 5; "Fossil point," Port Möller, Alaska, collected by W. H. Dall.
Aucella piochii, var. *ovata* STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 43, pl. 4, figs. 11, 12, 13 (not fig. 14); 2 miles north of Wilcox ranch, western Tehama County.
Aucella terebratuloides, PAVLOW, Soc. Imper. Nat. Moscou, Nouv. Mem., T. 17, 1907, p. 60, pl. 5, figs. 6, 7, 9, 10, 11; Neocomian of Russia and of California.

According to Pavlow, who figures three varieties of this species, its stratigraphical range in Russia is from Upper Jurassic (Portlandian) to lower Neocomian. It is not known to have such range in California, although some of its so-called "varieties" may have. One is recorded from the top of the Horsetown group in the McCarthy Creek section. Some references to *Aucella piochi* in the lower beds of the Shasta series found in the literature may be due to wrong determinations of some of these varieties. Stanton (Stanton and Diller, 1894, p. 447) includes this species in a list with "*Helicaulax*" *bicarinata*, "*Olcostephanus*," *Crioceras latum*, and *Belemnites impressus*, from a locality 2 miles north of the Wilcox ranch, which appears to be at the top of the Paskenta group. It is found most plentifully in the upper part of its lower division in the zone of *Dichotomites mutabilis* (Stanton).

Aucella inflata Toula

(Plate 8, figures 5, 6)

Aucella concentrica var. WHITE, U. S. Geol. Surv., Bull. 4, 1884, p. 11, pl. 6, fig. 11 only; "Fossil point," Port Möller, Alaska, collected by W. H. Dall.
Aucella inflata LAHUSEN, Mem. Com. Geol. St. Peterburg, vol. 8, no. 1, 1888, p. 20, 40, pl. 4, figs. 12-17; Lower Neocomian, Russia—PAVLOW, Soc. Imper. Nat. Moscou, Nouv. Mem. T. 17, 1907, p. 68, pl. 6, figs. 5a, b, c; Lower Neocomian of Pekhorka, Govt. of Simbirsk, Russia.

According to Pavlow this species has some resemblance to *A. terebratuloides* but differs from it in its greater degree of inflation, greater convexity of the right valve, and in the more stubby form of the shell and its more convex posterior border, which projects more to the rear.

In the type district of the Paskenta group this species is more abundant in its lower beds, where it occurs with *A. uncitoides*, *A. solida*, *Lytoceras saturnale*, nov., and a fine-ribbed species of *Phylloceras*. The species is also abundant near Winslow bridge, western Glenn County, in the lower beds of the Paskenta group, and in nearly the same horizon east and northeast of Knoxville, Napa County. Specimens of the same have been collected here by N. L. Taliaferro, apparently from the locality mentioned by Turner (1893, p. 316), who has described conglomerates found "in the Knoxville beds at several points" to the north of Knoxville. These conglomerates are the basal, or near-basal, beds of the Paskenta group. The same species has

been found near the base of this group 1½ miles northeast of Mount Diablo by Hoffer and Staples (Louderback, 1933), and also in basal conglomerates on the northwest flank of the mountain. It also occurs near Orchard Peak, Kern County, where it has been collected by Hanna and Church in the Devils Den district.

Aucella solida (Lahusen)

(Plate 10, figures 3, 4)

Aucella concentrica var. WHITE, U. S. Geol. Surv., Bull. 4, 1884, p. 13, 14, pl. 6, fig. 8; "Fossil Point," Port Möller, Alaska; U. S. Geol. Surv., Mon. 13, 1888, p. 232, pl. 6, fig. 13.

Aucella crassicollis var. *solida* LAHUSEN, Mem. Com. Geol. St. Petersburg, vol. 8, no. 1, 1888, pl. 5, figs. 14, 15; Lower Cretaceous of Russia.

Aucella solida (Lahusen) PAVLOW, Soc. Imper. Nat. Moscou, Nouv. Mem. T. 17, 1907, p. 64, pl. 5, figs. 24a, b, c; Lower Neocomian of Russia; figs. 25, 26; Shelton Ranch, near Paskenta, Tehama County, California.

This species has been found with *A. inflata*, *A. uncitoides*, and *Lytoceras saturnale*, nov., in the lower beds of the Paskenta group in its type district, and in the same horizon in the Devils Den district, Kern County, where it was collected by Hanna and Church. It has also been collected by C. F. Averill at Big Bar, Trinity County, associated with *A. crassa* and various plant remains, probably at one of the localities mentioned by Diller (1908, p. 379–382). According to Pavlow the species is found in the Lower Cretaceous of Russia, in the zone of *Subcraspedites stenomphalus* (Pavlow), which has been regarded as an Infra-Valanginian horizon in Russia and in England.

Aucella uncitoides Pavlow

Aucella piochii var. *ovata* STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 43, pl. 4, fig. 14 only; type district of the Paskenta group, Tehama County.

Aucella uncitoides PAVLOW, Soc. Imper. Nat. Moscou, Nouv. Mem. T. 17, 1907, p. 61, pl. 5, figs. 14, 15a, b; Lower Neocomian of Tobolsk and Simbirsk, Russia, and of the Lower Cretaceous in California.

This species is most abundant in the lower beds of the Paskenta group in its type district, especially on McCarthy Creek, western Tehama County, where it is associated with *A. inflata*, *A. solida*, and *Lytoceras saturnale*, nov., and with *Phylloceras* cf. *knoxvillense* Stanton. According to Pavlow the species occurs in Russia in the zone of *Subcraspedites stenomphalus* (Pavlow), thus indicating a low position in the Cretaceous sequence. *Subcraspedites stenomphalus* is regarded as an index fossil; Spath places it near the top of the Infra-Valanginian in the standard section of Europe.

South of Paskenta this species has been found at a number of places near the base of the group, as near Elk Creek village, Glenn County. Crook has collected the species with *A. crassicollis*, *Lytoceras* cf. *saturnale*, and others from the lower beds of the Paskenta group at the north end of the Berryessa Valley, Napa County. This locality is on the west side of Etiqura Creek, 3 miles above its mouth, and half a mile southwest of the Foster ranch. The coarse sandy beds here form the local base of the group, resting upon serpentine and other basement rocks.

Aucella piriformis Lahusen

(Plate 8, figures 3, 4)

Aucella concentrica var. WHITE, U. S. Geol. Surv., Bull. 4, 1884, p. 13, 14, pl. 6, figs. 6, 7; "Fossil Point," Port Möller, Alaska, collected by W. H. Dall.

Aucella piriformis LAHUSEN, Les Aucelles, p. 22, pl. 5, figs. 3–7; Lower Neocomian, Russia—PAVLOW, Soc. Imper. Nat. Moscou, Nouv. Mem. T. 17, 1907, p. 63, pl. 5, figs. 20–22; zone of *Polyptychites polyptychus* Pavlow; Lower Neocomian of Russia.

This species is found in the middle part of the Paskenta group in its type district, associated with *Neocomites jenkinsi*, species of *Astieria* (*s.s.*), *Berriasella*, and *Thurmannia paskentae*, nov. It has also been found at a higher level in the McCarthy Creek section—"zone P"—associated with *Lytoceras saturnale* and a large cycad leaf. Its occurrence here is in the middle third of the so-called "*Aucella crassicollis* zone," but it is not confined to this part of the section. This is the largest of the aucellan species found in these beds.

Aucella nuciformis Pavlow

(Plate 29, figures 7, 8, 9)

Aucella nuciformis PAVLOW, Soc. Imper. Nat. Moscou, Nouv. Mem., T. 17, 1907, p. 52, pl. 3, figs. 27a, b, c; figs. 28a, b, c; Lower Neocomian, zone of *Subcraspedites stenomphalus* Pavlow, Govt. of Simbirsk, Russia.

This species has not been recorded before from the Lower Cretaceous of California, but it has been found in the type district of the Paskenta group at three different points, and at two different horizons. It occurs in the basal sandy beds of this group at a locality 2 miles northwest of Paskenta, and in the same zone a quarter of a mile east of Henderson's house on McCarthy Creek. It has also been found at a higher level in this section, just beneath the zone of *Neocomites jenkinsi*, and with *A. piriformis* a little above it. It is not abundant at any place, but it is one of the forms recorded by Pavlow from the zone of *Subcraspedites stenomphalus* in the Lower Cretaceous of Russia.

Aucella keyserlingi Lahusen

Aucella keyserlingi LAHUSEN, Mem. Com. Geol., St. Petersburg, vol. 8, no. 1, 1888, p. 21, 40, pl. 4, figs. 18–23; Lower Neocomian, Russia.
Aucella crassicollis, var. STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 45–47, pl. 5, figs. 12, 13; "a specimen that approaches *Aucella piochii* var. *ovata*" Stanton.
Aucella keyserlingi, PAVLOW, Soc. Imper. Nat. Moscou, Nouv. Mem., T. 17, 1907, p. 62, pl. 5, figs. 17a, b, c, 18, 19; Lower Neocomian, Govt. of Simbirsk, Russia; zone of *Subcraspedites stenomphalus* (Pavlow).

Stanton (1895, p. 46) states that his figures (1895, pl. 5, figs. 12 and 13) are much like Lahusen's figure of *A. keyserlingi*, whereas Pavlow has regarded them as identical. In the type district of the Paskenta group this species has been found 600 to 800 feet above the base, associated with *Neocomites stippi*, nov., *Lytoceras saturnale*, and *Acroteuthis oncensis*, nov. It seems to be rather rare, but it is recorded here as one of the forms found in Russia in the zone of *Subcraspedites stenomphalus* (Pavlow). It is believed to have been found also on the west border of the Berryessa Valley. R. D. Reed sent a specimen probably of the same species to the California Academy of Sciences from Pasqual Creek, 3 miles south of Lompoc, Santa Barbara County, California.

Aucella lahuseni Pavlow

(Plate 8, figures 8, 9)

Aucella lahuseni PAVLOW, Soc. Imper. Nat. Moscou, Nouv. Mem., T. 17, 1907, p. 51, pl. 3, figs. 16–23.

In his description of this species Pavlow (1907, pl. 3, figs. 21a, b, c) has illustrated a form which is said to occur in Neocomian beds at Kachpour, Government of Sim-

birsk. The California forms, although of Neocomian age, more nearly resemble those illustrated by him (Pavlow, 1907, pl. 3, figs. 16a, b, c) from the Aquilonian beds of Khorochovo. The left valve is long and narrow, with an acuminate beak; the right valve is not less acute, but shorter. The species is found in the lowest beds of the Paskenta group on McCarthy Creek, Tehama County, and at the Government dam site, near Elk Creek village, Glenn County. The figured examples are from this locality. Good examples of the species were found by Bruce G. Martin at Locality 27 (Calif. Acad. Sci.), nearly 2 miles north of Myrtle Creek village, Douglas County, Oregon. The young of this species often resemble the young forms of *Aucella piochi* Gabb, but the more mature stages of growth are readily distinguished, being longer, narrower, and lacking the expansion of *A. piochi* in the posterior part of the left valve.

Aucella piochi Gabb

Inoceramus piochii GABB, Paleont. Calif., vol. 1, 1864, p. 187, pl. 25, fig. 173 only (not fig. 174); north side of Mount Diablo, Contra Costa County, California.
Aucella piochii GABB, Paleont. Calif., vol. 2, 1869, p. 194, (not pl. 32, figs. 92a, b, c) —STANTON (in part), U. S. Geol. Surv., Bull. 133, 1895, p. 42, (not pls. 4, 5).
Buchia piochi CRICKMAY, Am. Midl. Nat., vol. 13, no. 1, 1932, p. 1-7; (Upper Jurassic strata of Huasna district, San Luis Obispo County, California.

In the earlier literature on the Lower Cretaceous of California and Oregon, this species is often listed, and was usually regarded as indicating a low position in the Cretaceous sequence on the West Coast. More recently it has been held to be one of the leading species of the Knoxville series, and to range almost throughout this series. Search at the type locality of the species shows it to be not very abundant, but mingled with other species of the genus, and rarely among them a berriasellid, resembling *B. calisto* d'Orbigny. It is often found also in transported boulders buried in the basal conglomerates of the Shasta series, as on the northwest flank of Mount Diablo, and in the Berkeley Hills. A similar if not identical species has recently been collected from calcareous beds in the Berryessa Valley, Napa County, mingled with types of *Aucella* and other Mollusca that characterize the basal beds of the Paskenta group. For this reason the species is included here as one that in exceptional places in the Great Valley embayments may have survived the events which normally closed the Knoxville period. The species ranges throughout the Knoxville series in its type area.

Aucella indigenalis Anderson, n. sp.

(Plate 7, figures 5, 6; Plate 8, figure 10)

This species has the general form of *Aucella keyserlingi* Lahusen, as figured by Pavlow (1907, pl. 5, figs. 17a, b, c), but differs from it notably. The left valve has a higher and more prominent beak, which overhangs the right valve in a hook-like curve; the margins of the right valve meet above at a larger angle (near 85 degrees), and the umbonal ridge on the left valve is much more oblique.

The holotype (Calif. Acad. Sci. type Coll.) was found with other examples of the same species, at "Locality 77," 2 miles north of the Indian village of Skidegate, Graham Island, by R. M. Kleinpell and E. W. Galliher. It has the following dimensions: length of left valve, 55 mm.; greatest width, 35 mm.; thickness, 20 mm.; length of right valve, 42 mm.; width, 30 mm.; thickness, 10 mm.

It was found associated with *Lytoceras argonautarum* Anderson, *Desmoceras voyi* Anderson, and with other species of *Aucella*. It is regarded as being of Aptian age.

In its association with the above forms it recalls a species of *Aucella* found in the Barr zone of the Cottonwood district, California, also in Aptian strata.

OSTREIDAE Lamarck

Ostrea Linnaeus

Ostrea indigena Anderson, n. sp.

(Plate 1, figures 1, 2)

Shell large, thick, and massive; upper (right) valve irregularly semicircular, or ovate in outline, beak subterminal, posterior end rounded; valve moderately thick, concave, or excavated above; lower (left) valve high, thick, and angulated, massive; beak curving forward and toward the side; left valve strongly arched, with angular ridge extending from the beak to the posterior margin; slope steep toward the back, gentler toward the front; neither valve corrugated, or much roughened, marked only by the almost smooth edges of the lamellae, not showing transverse folds.

This shell bears much resemblance to *Ostrea couloni* Defrance, as figured by Weaver (1931, p. 229, pl. 19, figs. 90, 91), from the lower Neocomian of western Argentina, of which it is at least an analogue. Stanton (1895, pl. 2, fig. 1) has figured a small upper valve of a shell found near Stephenson's on the Cold fork of Cottonwood Creek, which may be the young of this species, since both are found in the Paskenta group, although not in the same horizon.

The holotype (Calif. Acad. Sci. type Coll.) measures: length, 145 mm.; greatest width, 95 mm.; thickness of both valves, 70 mm. This example was found by E. J. Broad at Locality 113 (Calif. Acad. Sci.), 4 miles southwest of Ono, Shasta County. Its horizon is in the upper part of the Paskenta group in the Cottonwood district. Another example of the same species was found by the writer in the NW ¼ Sec. 7, T. 29 N., R. 7 W. These examples were found on nearly the same horizon, and both were found associated with *Acroteuthis shastensis*, beneath the lowest beds assignable to the Horsetown group.

TRIGONIIDAE Lamarck

Trigonia Bruguière

Trigonia kayana Anderson, n. sp.

(Plate 7, figure 6)

Trigonia aequicostata DILLER and KAY, U. S. Geol. Surv., Geol. Atlas, Riddle Folio, 1924, p. 3, fig. 3; "Knoxville formation," Riddle Quadrangle, Oregon.

The shell of this species is small, or of only moderate size, as judged by the better-known forms with which the figure appears in the folio. The species is quite unlike *T. aequicostata* Gabb which occurs in the lower beds of the Chico series, and it requires a distinctive name. It seems to be among the oldest forms of *Trigonia* yet found in the West Coast Cretaceous. A similar form has been found on Eagle Creek, near Ono, Shasta County, in the lowest beds of the Horsetown group. At present the horizon of the Riddle example is subject to question, since it is included in a list of "Knoxville" forms, which includes *Aucella piochi* Gabb, *A. "crassicollis"* (= *A. crassa* Pavlow), and *Pecten operculiformis* Gabb, and a Ginkgo leaf. As these molluscan forms represent various distinct horizons they perhaps need revision.

A similar small undescribed species of *Trigonia* has been found in beds regarded as being in the middle part of the Paskenta group on the North fork of Cottonwood Creek, 2 miles southwest of Ono, Shasta County.

PECTINIDAE Lamarck

Pecten Müller

Pecten complexicosta Gabb

Pecten complexicosta GABB, Paleont. Calif., vol. 2, 1869, p. 199, pl. 33, figs. 97, 97a; "Shasta Group," Morgan Valley, Lake County—STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 37, pl. 2, figs. 7–9; Wilbur Springs, Colusa County—ANDERSON (in LAWSON), U. S. Geol. Surv., San Francisco Folio, 1914, p. 8; Berkeley Hills, Contra Costa County.

This shell is of moderate size, thin, equivalve, nearly equilateral; sides and base forming a regular curve; shell slightly elongated; surface marked by about 12 to 14 radiating ribs, with sometimes an equal number of intermediary ribs. The length of the holotype, about 57 mm.; width, 50 mm.

Gabb states that it is common in the limestone of Morgan Valley, Lake County. Stanton found it in the limestone south of Wilbur Springs, Colusa County, and it occurs in the Berkeley Hills, associated with *Atrcsius liratus* Gabb, and with other well-known species characteristic of the Paskenta group.

Pecten californicus Gabb

Pecten californicus GABB, Paleont. Calif., vol. 1, 1864, p. 201, pl. 31, fig. 270; Cottonwood Creek, Shasta County, California—STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 36, pl. 2, fig. 10; Cold fork of Cottonwood Creek, Tehama County.

This small species of *Pecten* occurs in both the Paskenta and Horsetown groups, and both north and south of the delta area on the west border of the Sacramento Valley. Gabb seems to have confused this species with another occurring in the Chico series, giving the horizon of its occurrence as "Chico or Shasta group," Cottonwood Creek. It has not been seen by the writer in the Chico series; Stanton reported it from "near Stephenson's on the Cold fork of Cottonwood Creek, in beds near the base of the Paskenta group, of the Shasta series, where it occurs with many other species listed by him (Stanton, 1895, p. 14). The same species has been found abundantly in the lower part of the Horsetown group on McCarthy Creek, a quarter of a mile west of the Lowry Road.

Syncyclonema Meek, 1864

Syncyclonema operculiformis (Gabb)

Pecten operculiformis GABB, Paleont. Calif., vol. 1, 1864, p. 201, pl. 28, fig. 188; vol. 2, 1869, p. 200, 251; Cottonwood and Hulen creeks, Shasta County, and Curry's near Mount Diablo—STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 16, 18, 32, 37; regarded as occurring in both Shasta and Chico series—STEWART, Phila. Acad. Nat. Sci., Spec. Publ. no. 3, 1930, p. 120; locality not given.

The simple form and unornamented character of this shell has made its specific description difficult. It is flatly lenticular, subcircular in outline below the auricles; interior of the shell silky in texture, smooth, or polished without, but showing fine concentric lines of growth; left valve with nearly equal auricles, right valve less well known. The holotype ("lectotype" of Stewart) is in the Museum of Paleontology, University of California. It has the following dimensions: length, 22 mm.; height, 26.5 mm.; thickness, about 3 mm. Similar forms are found in many parts of the Shasta series, and for this reason the range of the species is not definitely known.

Stewart gives the umbonal angle of the holotype as 100 degrees, and if the same species has a stratigraphic range throughout the Shasta series this angle is variable; if the angle is regarded as diagnostic of species, there may be several species in the series.

Neithea Drouet

Neithea grandicosta Gabb

Neithea grandicosta GABB, Paleont. Calif., vol. 2, 1869, p. 200, pl. 33, figs. 99, 99a; rare in the "Shasta Group," Cottonwood Creek, Shasta County—ANDERSON, Calif. Acad. Sci., Pr., vol. 2, 1902, p. 41; Horsetown group, Shasta County.
Neithea (Neitheops) grandicosta, STEWART, Phila. Acad. Nat. Sci., Spec. Publ. no. 3, 1930, p. 116; new subgenus proposed.

Gabb's description of this species reads in part:

"Shell minute, very inequivalve, equilateral, elongate; lower valve, sides tapering a little concavely; general contour of the base semicircular, with six prominent angles and concave interspaces. Surface marked with six very large, round, equidistant ribs, the interspaces carrying a small rib, flanked on each side by one still smaller; . . ."

This species seems to be very rare in the Shasta series, and only the holotype has been known. Its horizon was not given by Gabb, and its exact locality has been conjectural. Recently a single valve clearly identifiable with the species has been found in the Barr zone of the Horsetown group, near the small school on Mitchell Creek, 5 miles south of Ono, Shasta County. Its length is 13 mm.; height, nearly the same. It was found associated with *Acroteuthis aboriginalis*, nov., *Terebratella averilli*, nov., and *Parahoplitoides* sp. Its occurrence in the thin conglomerate of this zone fixes its horizon here as in the lower Aptian beds of the Horsetown group.

SPONDYLIDAE Fleming

Spondylus Linnaeus

Spondylus fragilis Stanton

Spondylus fragilis STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 35, pl. 2, fig. 3; near Stephenson's, on Cold fork of Cottonwood Creek, Tehama County.

This species was described from a small left valve, showing well-defined, subequal ears, low beak, and irregularly undulating radial lines upon the surface. These lines are said to show a tendency to become subspinose on well-preserved examples. The species is one of the 18 molluscan forms specifically named by Stanton (1895, p. 14) in the list obtained near Stephenson's on the Cold fork of Cottonwood Creek. It was believed to belong in "the upper part of the Knoxville beds," but as the list also contains various other diagnostic species belonging in the Shasta series (Lower Cretaceous), it can hardly be regarded as representing Knoxville beds in the sense of this paper. The list includes *Cyprina occidentalis* Whiteaves, *Aucella crassicollis* Keyserling, and *Acroteuthis impressa* (Gabb); the last two of these indicate that the horizon is not older than the Paskenta group, and in fact is found near its base at this locality.

Plicatula Lamarck

Plicatula variata Gabb

Plicatula variata GABB, Paleont. Calif., vol. 1, 1864, p. 203, pl. 26, fig. 190, Battle Creek, Shasta County; vol. 2, 1869, p. 252; "Shasta Group," Battle Creek,

Shasta County—STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 18; the species is included in a list from the lower Horsetown beds in the Cottonwood district, Shasta County.

Gabb's description is in part as follows:

"Shell variable, usually somewhat curved. Lower valve attached by a portion of the surface, deep, radially costate, ribs occasionally dichotomous. Upper valve flat or concave, plicate like the lower, but not so strongly, ribs being sometimes obsolete. Hinge robust; muscular scar large; internal margin of the upper valve crenate [crenulated]; lower valve marked with pits corresponding to the teeth above." Average length of the shell is about 18 mm.

This species is characteristic of the lower Horsetown beds, and has not been found by the writer in the Chico series, as might be thought likely from Gabb's note as to its occurrence on Battle Creek.

Plicatula onoensis Anderson, n. sp.

(Plate 4, figures 1, 2, 3)

Shell small, semi-triangular, very inequivalve, often concavo-convex; lower valve more convex, showing little evidence of attachment; surface highly convex, ornamented by 8 to 12 sharp, radial ribs, some of which bear scale-like spines where intersected by the strong lines of growth; upper valve usually concave, or flattened, ornamented by 6 or more radial rounded plications.

The holotype (Calif. Acad. Sci. type Coll.) was found on the North fork of Cottonwood Creek, 600 feet above the bridge at Ono. The species is also abundant in the upper beds of the Paskenta group, and has been found at Locality 113 (Calif. Acad. Sci.), 4 miles southwest of Ono, where it occurs about 600 feet beneath the lowest beds assignable to the Horsetown group. It occurs here associated with *Polyptychites shastensis*, nov. and *Crioceras* cf. *latum* Gabb.

LIMIDAE d'Orbigny

Lima Bruguière

Lima multilineata Stanton

Lima multilineata STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 36, pl. 2, figs. 4, 5; near Stephenson's on Cold fork of Cottonwood Creek, Tehama County.

This shell is well figured and described by Stanton and needs no further note as to its characteristics. Stanton compares it with *Lima microtis* Gabb from the Chico series (Cottonwood Creek), but states that the shell is large and less oblique than the latter. This species is among the number listed by Stanton (1895, p. 14), all of which are included in this memoir in the lower beds of the Paskenta group.

The species is not abundant in these beds, but it has been found in a few places in this horizon. A good example of the species was obtained in 1912 from the old "cement-rock" quarry at Napa Junction, Sonoma County, 4 miles north of Vallejo, where it was associated with *Inoceramus vallejoensis*, *Modiolus onoensis*, nov., and numerous pholad borings, the latter indicating stratigraphic disconformity.

Lima shastensis Gabb

Lima shastensis GABB, Paleont. Calif., vol. 2, 1869, p. 201, pl. 33, fig. 100; "Shasta Group," Cottonwood Creek, Shasta County—WHITE, U. S. Geol. Surv., Bull. 15, 1885, p. 20; Horsetown beds—STEWART, Phila. Acad. Sci., Spec. Publ. no. 3, 1930, p. 124, pl. 15, fig. 13; locality not given.

The shell of this species is small, compressed irregularly subelliptical, equivalve; anterior side and base forming a regular curve, the posterior margin of the base curving upward rather abruptly to the posterior end, which is straight; ears very small, the anterior ear triangular, the posterior, narrow, almost linear; posterior umbonal slope very narrow; surface ornamented by 20 or 21 prominent, straight, radiating ribs, with interspaces of equal size. Stewart gives the following measurements for the holotype, which is in the collections of the Academy of Natural Sciences of Philadelphia: length, 15.5 mm.; height, 14.2 mm.; thickness of left valve, about 2 mm.

ANOMIIDAE Gray

Anomia Linnaeus

Anomia senescens Stanton

Anomia senescens STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 35, pl. 2, fig. 2; 2 miles south of Lowry's, Tehama County.

In his description of this shell Stanton says, in part:

"Shell rather large, subcircular in outline, slightly oblique, depressed, convex; hinge line straight, nearly as long as the shell; beak inconspicuous, not projecting beyond the hinge line and situated near the middle of it; surface marked by faint concentric undulations. Length, 25 mm.; height, 23 mm."

This species is included in a list of six specifically named forms given by Stanton (1895, p. 17) from a locality 2 miles south of Lowry's. The associated forms include *Aucella crassicollis*, *"Olcostephanus" trichotomous*, and others, all of which are characteristic of the upper part of the Paskenta group. Stanton states that the specimen was inside a fragment of *Lytoceras batesi*, a species not known below the Horsetown group, and therefore indicating the age of the present species.

Whiteaves has described a similar form from Lina Island (Queen Charlotte Islands), which is included by Stanton (MacKenzie, 1916, p. 66) in the Haida formation, under the name *Anomia linensis* (Whiteaves). Although MacKenzie indicates no older Cretaceous strata on Lina Island, there are stratigraphic reasons for expecting them there. The form described by Stanton has not been found in the Knoxville series.

MODIOLOPSIDAE Fischer (emend.)

Myoconcha Sowerby

Myoconcha americana Stanton

Myoconcha americana STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 48, pl. 2, fig. 11; near Stephenson's, Cold fork of Cottonwood Creek, Tehama County.

"Shell small, slender, subovate, gently convex; beak small, almost terminal; dorsal margin nearly straight, passing by a gentle curve into the rounded posterior end; ventral margin also nearly straight, slightly contracted toward the front, gently convex behind; shell gradually broadening from the narrow anterior end for about two-thirds of its length, and thence rounded to the posterior end, surface marked by lines of growth. Length, 41 mm.; greatest width, 22 mm."

This species is among those contained in Stanton's list (1895, p. 14) of molluscan forms collected from the basal beds of the Paskenta group near Stephenson's on the Cold fork of Cottonwood Creek. Of the 24 forms in this list, 18 are specifically named, (some doubtfully), of which 13 are new, and described from this locality; 2 species are known from the Cretaceous of Queen Charlotte Islands; 3 are well-known Shasta species, of which *Pecten californicus* and *"Belemnites" impressus* are

common in the Horsetown group. *Aucella crassicollis* pertains to the Paskenta group. None of the species have been recorded from the Knoxville (Upper Jurassic) series, nor have any been found there by the writer. From an analytical study of the list it must be concluded that the locality must be included in the Paskenta group, and an examination of the beds shows them to immediately overlie a heavy conglomerate marking an unconformity at the base of this group.

MYTILIDAE Fleming

Mytilus Linnaeus

Mytilus arlingtoni Henry (unpublished)

(Plate 1, figure 8)

Shell of medium size, obliquely crescent-shaped; beaks terminal, narrowly rounded; cardinal line slightly curved, curve accentuated in the more strongly arched posterior border; anterior margin slightly concave in young stages of growth, more strongly concave in older shells; valves strongly arched (inflated), when seen from the front; dorsal slope bearing a subsidiary fold parallel to the umbonal ridge; test thick.

The holotype is in the Museum of Paleontology, University of California. It has the following dimensions: total length, 91 mm.; height, 40 mm.; convexity of single valve, 38 mm. Another example of the same species was found at the same locality. These were found by Leonard W. Henry on the south border of Contra Costa County, near Arlington Avenue at the north border of Berkeley. They were found associated with other invertebrates, including *Balanus* sp., *Aucella crassicollis*, *A. inflata*, and *Belemnites* sp. These fossils were found in a calcareous pebbly sandstone overlying Knoxville beds with clear evidence of unconformity, as shown in part by some of the associated forms. The horizon represented is in the lower part of the Paskenta group of the Shasta series.

Modiolus Lamarck

Modiolus major (Gabb)

Modiola major GABB, Paleont. Calif., vol. 2, 1869, p. 191, pl. 13, fig. 88; white limestone of the "Shasta Group," east of Knoxville, Napa County—STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 48 (in part, not pl. 3, fig. 1)—ANDERSON, Calif. Acad. Sci., Pr., vol. 2, 1902, p. 45; north border of Berkeley, California; Paskenta group.

Myoconcha major (Gabb) STEWART, Phila. Acad. Sci., Spec. Publ. no. 3, 1930, p. 104, pl. 4, fig. 1; probable holotype.

Gabb's holotype of this species seems to have been taken to the Academy of Natural Sciences of Philadelphia, and Stewart has figured an example found there as probably the holotype. The species occurs in the white limestone 1¼ miles southwest of Wilbur Springs, Colusa County, associated with *Rhynchonella whitneyi* Gabb and *Pecten complexicosta* Gabb. An imperfect example of this species is in the California Academy of Sciences from this locality, and is readily identified with Gabb's form. The same species has been obtained from the white limestone of the same horizon on the west side of the Berryessa Valley, collected by Eldridge D. Drew and donated to the Academy. The same species occurs in a calcareous sandstone of the Paskenta group in the Berkeley Hills near Berkeley. The measurements of the holotype given by Gabb are: length, 4.8 inches; height, 2.4 inches; thickness, 1.5 inches. The ratio of height to length given by Stewart for the probable holotype is .480:1, which is somewhat more slender than as stated by Gabb.

Modiolus stantoni Anderson, n. sp.

Modiola major (Gabb) STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 48, pl. 3, fig. 1; one mile east of Stephenson's, Cold fork of Cottonwood Creek, Tehama County.

Although Stanton believed that his specimen represented Gabb's "*Modiola*" *major*, a comparative study of various examples and the figures given by Gabb and Stanton shows various specific differences. Stanton (1895, pl. 3) notes that his example "is not quite so slender as Gabb's original figure," and this fact is readily seen. In Stanton's example the shell is much larger, and the ratios of length to height is 1:.556; thickness not given.

A fairly well preserved example of this species found by Drew on the west border of Berryessa Valley in white limestone shows a ratio of length to height of 1:.686, and a ratio of length to thickness of 1:.466. It is 6 inches in length.

There are other differences; the beaks in *Modiolus major* are more nearly terminal, and the umbonal ridge forms a smaller angle with the base than in *Modiolus stantoni*. Both species occur in the white limestone on the west border of the Berryessa Valley, associated with *Aucella piriformis*, *Inoceramus ovatus*, and many other forms common in the Paskenta group.

Modiolus (*Volsella*) *onoensis* Anderson, n. sp.

(Plate 2, figure 5)

Shell small, subcylindrical, elongate, smooth; beaks nearly terminal, low, rounded; hinge line nearly straight, one-half the length of the shell; posterodorsal margin broadly curved to posterior end; anterior end narrowly rounded below the beaks; ventral border nearly straight; lower part of the side somewhat pinched near the middle; surface smooth, or marked only by concentric lines of growth, inner layer of test pearly. The holotype (Calif. Acad. Sci. type Coll.) was found on the North fork of Cottonwood Creek, half a mile above the bridge at Ono. Length of holotype, 47 mm.; greatest width, 17 mm.; thickness of both valves, 16 mm.

Its stratigraphic position is near the top of the Paskenta group 400 feet below the base of the Horsetown. It was found associated with *Plicatula variata* Gabb, *Crioceras* cf. *latum* Gabb, and other pelecypods. A nearly related species, *M.* (*Volsella*) *henryi*, was found by L. W. Henry in the Paskenta beds in the northern part of Berkeley.

Modiolus (*Volsella*) *henryi* Anderson, n. sp.

(Plate 2, figure 6)

Shell small, subovate in outline, moderately compressed or narrowly lanceolate when seen from above; cardinal and lower margins nearly straight, the former curving regularly into the rounded posterior border; beaks nearly terminal, closely approximate, rounded below, anterior end curving sharply to the basal border.

The holotype and four other well-preserved examples were found by Leonard W. Henry at the north border of Berkeley, near Arlington Avenue; they are in the Museum of Paleontology, University of California. They were found in strata not far above the basal bed of the Paskenta group. The holotype has the following dimensions: length, 20 mm.; height, 13 mm.; greatest convexity, 10 mm.; length of largest example found, 29 mm.

Pleuromyacidae Zittel

Pleuromya Agassiz

Pleuromya papyracea Gabb

Pleuromya papyracea Gabb, Paleont. Calif., vol. 2, 1869, p. 178, pl. 29, fig. 66; Cottonwood Creek, Shasta County, "Shasta Group"—Stanton, Jour. Geol., vol. 5, 1897, p. 597, 598; Horsetown beds—Stewart, Phila. Acad. Sci., Spec. Publ. no. 3, 1930, p. 303, pl. 2, fig. 5; Gabb's holotype figured, locality as given by Gabb.

Stewart includes this species doubtfully in the genus *Pleuromya*, but does not indicate any more appropriate genus for it. The shell is thin and not often preserved. Good casts have been obtained at various places and at different horizons north of the delta, which show a range from the lower beds of the Paskenta group to the top of the Horsetown. Two good examples were found at Locality 1659 (Calif. Acad. Sci.) in the Neptune zone of the Hulen beds, 450 feet beneath their top, and also at Locality 1668 (Calif. Acad. Sci.), 200 feet lower in the section. These examples fully conform to the characters of the holotype as figured by Stewart, but less to Gabb's figures. As suggested by Stewart, Gabb's figures were often "reconstructed."

At Locality 1659 (Calif. Acad. Sci.) the species is associated with *Beudanticeras breweri* (Gabb) and *Douvilleiceras mammillatum* var. Stewart gives the following dimensions for the holotype: length, 45.5 mm.; height (incomplete), 20 mm.; thickness of both valves, 20 mm.

The same species has been found at Locality 1665 (Calif. Acad. Sci.) on Duncan Creek, associated with *Crioceras latum* Gabb and *Spiticeras duncanense* nov. Smaller examples that seem referable to the same species have been collected on Eagle Creek, near Ono, and at Clements ranch on Redding Creek, Trinity County.

Pholadomyacidae Gray

Pholadomya Sowerby

Pholadomya hulenana Anderson, n. sp.

(Plate 3, figures 1, 2)

Shell of medium size, robust, triangular in outline, umbones high, anterior to center of shell, inflated, beaks curving forward and inward, approximate; shell excavated in front of beaks; posterior cardinal margin sloping moderately steep, anterior slope much steeper, the two slopes forming an angle of about 90 degrees; the anterior margins of the valves meeting in a narrow ridge beneath the beaks; anterior and basal borders closed; posterior end apparently open; surface of shell ornamented with narrow beaded costae radiating from the beaks toward the basal margin, more prominent on the anterior part of the shell.

The species somewhat resembles *Pholadomya harrigani* Hall and Ambrose, from the Upper Cretaceous beds near Altamont, Alameda County, but the horizon of the present species is much lower in the general section, and the form of the anterior end of the shell is less abrupt. The holotype of the present species (Calif. Acad. Sci. type Coll.) was found at Locality 1668 (Calif. Acad. Sci.) on the west branch of the east fork of Hulen Creek, in the Perrin zone. Its measurements are as follows: length (incomplete), 50 mm.; height, 40 mm.; thickness of both valves, 33 mm. It was found associated with *Pinna equivillana*, *Sonneratia rogersi* Hall and Ambrose, *Cleoniceras modeste*, and *Nautilus gabbi* Anderson. The horizon is probably lower middle Albian, on the European scale.

Pholadomya russelli Anderson, n. sp.

(Plate 5, figures 3, 4)

Shell of medium size, robust, oval in outline, umbones elevated, anterior; beaks incurved, approximate, excavated before and behind; posterior dorsal margin sloping gently, rounded uniformly to the rounded posterior end; anterior end more broadly rounded to the basal border; surface marked by somewhat regularly concentric ridges, which become fainter on the posteror quarter of the shell; faint plications visible on the anterior end below the beaks; section of shell near the umbones cordate; posterior end thin, section narrow.

The holotype (Calif. Acad. Sci., type Coll.) was found by R. Dana Russell at Locality 1659 (Calif. Acad. Sci.) in the Neptune zone on Hulen Creek, Shasta County. It has the following measurements: length, 63 mm.; height, 46 mm.; greatest thickness of both valves, 38 mm.

Six fairly well preserved examples of the species were obtaned here, associated with *Puzosia subquadrata* (Anderson), *Beudanticeras breweri* (Gabb), *Lytoceras duvaliforme*, nov., *Douvilleiceras mammillatum* var., and other species. The horizon of this species is about 450 feet beneath the local top of the Hulen beds, and about the same distance above that of the preceding species.

Pholadomya altumbonata Anderson, n. sp.

(Plate 5, figures 5, 6)

Shell small, inflated, subquadrate in outline; beaks high, near the anterior end, excavate in front, strongly incurved, approximate; anterior end short, rounded, curving to the rounded base; posterior end more produced, gaping; surface marked only by concentric ridges which become weakened on the after part of the shell; shell thin.

The holotype (Calif. Acad. Sci. type Coll.) and many other examples of the species were collected by N. E. A. Hinds near the Clements ranch on Redding Creek, eastern Trinity County. The holotype has the following measurements: length, 41 mm.; height, 33 mm.; thickness of both valves, 27 mm. The species somewhat resembles *Pholadomya russelli*, but it is smaller, has more prominent beaks, and a more produced posterior part. All the examples obtained were from the same point, where they were associated with *Pholadomya clementina*, and *Phylloceras* cf. *trinitense* nov., and they were found in strata near the horizon of the holotype of *Crioceras latum* Gabb. This horizon is believed to be in the upper part of the Paskenta group.

Pholadomya clementina Anderson, n. sp.

(Plate 3, figure 3)

Shell small, little inflated, oval in outline; umbones high, subcentral, angulated; beaks incurved, approximate, excavated behind; posterior dorsal margin rounded, curving regularly to the narrowly rounded posterior end; anterior end sloping rapidly to the basal border; surface smooth, or having only faint concentric lines of growth. The most characteristic feature of the shell is the umbonal angle, extending from the umbones to the angular anterio-basal border.

The holotype (Calif. Acad. Sci. type Coll) was found by N. E. A. Hinds near the Clements ranch on Redding Creek, eastern Trinity County, associated with the preceding species. It has the following measurements: length, 37 mm.; height, 28 mm.; thickness of both valves, 18 mm.

The horizon is that of the preceding species, which is believed to be in the upper

part of the Paskenta group. This species has been found also on Eagle Creek, near Ono, in the lowest beds of the Horsetown group, which shows its range in the general section of this region.

Pholadomya distorta Anderson, n. sp.

(Plate 3, figures 9, 10)

Shell small, subtriangular, somewhat inflated, subcordate in section near the beaks; beaks anterior, high, incurved, approximate; shell truncated in front, margin broadly rounded to the rounded basal border; posterior dorsal slope steep to the narrowly rounded posterior end; surface marked by concentric lines of growth only. The distinguishing features of this shell are its exaggerated beaks, truncated anterior margin, and its steep posterior slope.

The holotype (Calif. Acad. Sci., type Coll.) was found at Locality 1691 (Calif. Acad. Sci.) by G. D. Hanna near the Clements ranch on Redding Creek, eastern Trinity County. It has the following measurements: length, 35 mm.; height, 40 mm.; thickness of both valves, 27 mm.

The horizon of its occurrence is somewhat higher than that of the preceding species, but it is well within the limits of the Paskenta group. A single example, probably of the same species, was found at old Horsetown, in the uppermost beds of the Horsetown group, associated with *Puzosia hoffmanni* (Gabb) and *Beudanticeras breweri* (Gabb).

Goniomya Agassiz

Goniomya vespera Anderson, n. sp.

(Plate 3, figures 4, 5)

Shell small, elongate, slender, subquadrate in transverse section, depressed; umbones low, nearly terminal; beaks small, strongly incurved, closely approximate, and overhanging the end of the cardinal area; posterior dorsal margin straight, rather long; posterior end apparently rounded; anterior portion short, sharply rounded, open below; surface marked by a V-shaped sculpture, consisting of rimples, or thin, raised ridges extending obliquely downward from the posterior cardinal area, and finer, more oblique plications extending from the short anterior slope downward, meeting the former set along a slight umbonal ridge descending from the umbones obliquely downward and backward. The plications on the lower half of the shell are nearly parallel with the basal margin of the shell.

The holotype (Calif. Acad. Sci. type Coll.) was found by N. E. A. Hinds near the Clements ranch on Redding Creek, eastern Trinity County. It has the following measurements: length (incomplete), 19 mm.; height, 9 mm.; thickness of both valves, 10 mm. The holotype was found associated with *Periploma trinitensis* nov., *Phylloceras clementsi*, and *Pleuromya papyracea* Gabb.

As already stated, the horizon of this species is believed to be in the upper part of the Paskenta group. This species is the only representative of the genus yet found in the Lower Cretaceous of California, although Whiteaves (1884, p. 225) records one in the upper Neocomian rocks of Fraser River. A similar form, perhaps the same, was found by Parker D. Trask and the writer in Lower Cretaceous beds on Rattlesnake Creek, a few miles east of Forest Glen, Trinity County.

ANATINIDAE Dall

Periplomya Conrad, 1870

The application of this name by Conrad to American Cretaceous forms of Anatinidae has been reviewed by Stewart. Conrad has suggested the name *Leptomya* for a

species found in the Ripley formation of the Atlantic states, stating that the genus may also include the Lower Cretaceous *"Periploma" robinaldina*, *P. neocomiensis*, and *P. simplex* of d'Orbigny. Finding later that *Leptomya* was preoccupied, Conrad substituted the name *Periplomya* for the group. Stewart expresses the belief that the genotype, *P. applicata* (Conrad), is congeneric with certain species of *Thracia*. This surmise may be well founded, yet for the present it seems best to retain Conrad's inclusion of the genus in Anatinidae Dall. At least two species of this genus have been found in the Lower Cretaceous of California, both apparently belonging to the group of *Periplomya robinaldina* (d'Orbigny).

Periplomya trinitensis Anderson, n. sp.

(Plate 2, figure 7)

Shell of medium size, elongate, a little inflated, oval or elliptical in outline; umbones subanterior, about one-fourth the length of the shell from its forward end; beaks incurved, approximate; shell excavated before and behind the beaks; posterior cardinal margin straight, nearly parallel to the base, rounded behind to the narrowly rounded end; anterior portion short, abruptly rounded to the basal border; basal border straight in its forward two-thirds, curving upward behind; surface marked by weak concentric growth lines; a subangular ridge extending from the umbones downward to the base; valves but little open behind.

The holotype (Calif. Acad. Sci. type Coll.) was found by N. E. A. Hinds near Clements ranch on Redding Creek, eastern Trinity County, associated with *Phylloceras clementsi*, nov. and *Pholadomya clementina*, nov. It has the following measurements: length, 52 mm.; height, 27 mm.; thickness of both valves, 20 mm.

Periplomya reddingensis Anderson, n. sp.

(Plate 3, figure 8)

Shell of medium size, elongate, inflated in the umbonal region, subelliptical in outline; umbones situated near the anterior end, rather prominent and broad; beaks incurved, approximate; shell excavated beneath the beaks; cardinal margin nearly straight, curving gradually down behind to the rounded posterior end; anterior portion shorter, more abruptly rounded, forming a short subangular bend to meet the anterior basal border; basal border rounded behind, but with a slightly concave outline beneath the umbones. This species is larger and more inflated about the umbones than the preceding form, and possesses a more open, broader cardinal area. The valves are also somewhat more open behind than the preceding species.

The holotype (Calif. Acad. Sci. type Coll.) was found by G. D. Hanna at Locality 1691 (Calif. Acad. Sci.) half a mile northeast of the Clements ranch house on Redding Creek, eastern Trinity County. It has the following measurements: length, 59 mm.; height, 32 mm.; thickness of both valves, 23 mm.

The holotype and other examples of the species were found associated with *Panope* sp., *Pleuromya papyracea* Gabb, *Periplomya trinitensis*, nov., *Pholadomya altumbonata*, nov., and *Venus collinae*, nov. The horizon is believed to be that of the upper part of the Paskenta group.

PLEUROPHORIDAE Dall

Arctica Schumacher

Arctica occidentalis (Whiteaves)

Cyprina occidentalis WHITEAVES, Mes. Foss., vol. 1, 1884, p. 227, text figure 10—STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 60, pl. 12, fig. 2; near Stephenson's, Cold fork of Cottonwood Creek, Tehama County.

This shell is described by Stanton (1895, p. 60) as follows:

"Shell of medium size, with thick test, subovate in outline, depressed; beaks broad, rather prominent, and situated considerably in advance of the middle; dorsal border descending abruptly with a concave outline in front of the beak and sloping more gently behind, where it is straight or slightly convex; anterior end rather narrowly rounded; posterior end broader and subtruncate below; ventral margin forming a regular broad curve; surface marked by prominent but somewhat irregular concentric lines.

Length, 60 mm.; height, 50 mm.; convexity of single valve, about 16 mm."

The genus *Arctica* is not often found in the West Coast Cretaceous, and its occurrence in the lowermost beds of the California Cretaceous is therefore noteworthy. This species is included by Stanton (1895, p. 17) among the number found near Stephenson's, which is here shown to belong in the lowest beds of the Paskenta group.

SOLENIDAE Leach

Solecurtus de Blainville

Solecurtus ? dubius Stanton

Solecurtus ? dubius STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 61, pl. 10, figs. 4, 5; Cold fork of Cottonwood Creek, Tehama County.

Although this form is placed under *Solecurtus* by Stanton, he did not feel sure of its position. This genus has not been otherwise recorded from the Lower Cretaceous of California, and its occurrence needs confirmation. The species is included in a list of 18 forms specifically named from its type locality (Stanton, 1895, p. 14), some of which clearly indicate that the locality should be included in the Paskenta group. A visit to this locality confirms its position and age as being near the base of this group, but no further data were obtained.

ASTARTIDAE d'Orbigny, emend. Dall

Representatives of record are not abundant in the Lower Cretaceous of the West Coast. The discovery of a few species by Stanton in the lower part of the Shasta series is the earliest record of their appearance in California. They are found only in scattered localities in Tehama, Colusa, and Lake counties, and in every case in the Paskenta group, associated with other diagnostic species of the same.

Astarte Sowerby

Astarte corrugata Stanton

Astarte corrugata STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 56, pl. 6, fig. 16; Shelton ranch, 5 miles north of Paskenta, Tehama County; "upper part of the Knoxville beds."

This species is described as "very small, subtriangular, moderately convex; beaks prominent, acute; cardinal margin sloping rapidly both in front and behind; ventral margin convex, most prominent behind the middle; surface marked by a few very prominent, distant concentric ridges and by fine lines of growth; ventral margin crenulated within. Length of largest specimen seen, 5 mm.; height, 4 mm.; convexity of single valve, about 1 mm."

This species is included in a list (Stanton, 1895, p. 18) of specifically named forms, including such typical Paskenta species as *Aucella crassicollis*, *"Hoplites" angulatus*, *"Oleostephanus" mutabilis* Stanton, and others. The horizon is in the Valanginian, upper part of the Paskenta group, although Spath (1924, opp. p. 80) places the last-named species in the Infra-Valanginian.

Astarte californica Stanton

Astarte californica STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 57, pl. 6, figs. 19–21; "upper part of the Knoxville beds," near Stephenson's, Cold fork of Cottonwood Creek, Tehama County.

Stanton's excellent detailed description of this species needs no special comment except as to its assignment to the Knoxville series. The species is included in a list of 18 molluscan species (Stanton, 1895, p. 14), which also contains *Aucella crassicollis*, *Lima multilineata*, and *Acroteuthis impressa* (Gabb), all of which are characteristic of the lower part of the Paskenta group of the Shasta series. It appears, however, that this species has a greater vertical range than others of this list, since it has been found in the lower part of the Horsetown group—the Ono zone—at Locality 1353 (Calif. Acad. Sci.) near the bridge at Ono, Shasta County. By its position as well as by its fauna, the type locality of this species must be regarded as near the base of the Paskenta group.

Astarte trapezoidalis Stanton

Astarte trapezoidalis STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 57, pl. 8, figs. 17, 18; 3 miles south of Lowry's, Tehama County.

This species has been adequately described and figured by Stanton, who has also stated that it has been found at other localities. The locality given for the holotype as 3 miles south of Lowry's places it well within the limits of the Paskenta group, and its occurrence near Reiff, Lake County, associated with *Pecten complexicosta*, *Aucella crassicollis*, and *Turbo wilburensis* supports this conclusion. Like the two preceding species this one must also be regarded as representing a low position within the Paskenta group, and a Valanginian horizon.

Opis Defrance

Opis californica Stanton

Opis californica STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 58, pl. 7, figs. 1–7; near Stephenson's, Cold fork of Cottonwood Creek, Tehama County.

This is the first record of the occurrence of *Opis* in the Lower Cretaceous of California, although others have since been found. The description given by Stanton is in part as follows:

"Shell of medium size, with the outline triangular when viewed from the side, and cordate in profile; beaks submedian, narrow, prominent, incurved, and approximate; surface divided by a sharply angular umbonal ridge into two distinct areas, of which the posterior one is nearly plane and so abruptly deflected that it is scarcely visible from the side view, although it embraces about one-third of the total surface of the valve; front and ventral margins regularly curved from lunule to the end of the umbonal ridge, where it forms an angle of about 80° with the truncated and deflected posterior end; surface marked by fine lines of growth and more distant, irregular, concentric furrows; lunule cordate, large and very deep, with its border narrowly rounded; . . . The hinge shows the characteristic structure of the genus, with a single very large striated triangular tooth in the right valve and two smaller ones in the left, of which the anterior is fused with the edge of the shell."

The rarity of this genus in the Lower Cretaceous of California is one of its most striking aspects. Its stratigraphical position is in the lower part of the Paskenta group. It is listed by Stanton (1895, p. 14) with 18 specifically named forms, including *Aucella crassicollis* and *Belemnites impressus*.

Opis shastalis Anderson, n. sp.

(Plate 4, figures 4, 5)

Shell small, obliquely ovate, cordate; beaks high, rounded, smooth, closely approximate, curving inward; valves subtriangular in outline, base broadly rounded; hinge short, teeth not showing; surface smooth, polished, pearly, showing indistinct growth lines; umbonal ridge oblique to hinge line, nearer to the anterior margin; lunule small, impressed, not deep, lanceolate; shell flattened slightly behind the beaks. Two single valves of this shell were obtained, of which the holotype (Calif. Acad. Sci. type Coll.), measures: length near base, 17 mm.; height, 17 mm.; thickness of single valve, 9 mm.

Both examples were obtained at Locality 1347 (Calif. Acad. Sci.) on Mitchell Creek, a few feet above the conglomerate of the Barr zone, where they were associated with *Lytoceras* (*Gabbioceras*) *angulatum* and *Acroteuthis aboriginalis*, nov., near the lower limit of the Aptian portion of the Horsetown group.

LUCINIDAE Fleming

Lucina alcatrazis Anderson, n. sp.

(Plate 5, figure 7)

Shell rather large, subcircular in outline, little inflated, ends rounded, curving regularly to the rounded basal border; posterior dorsal margin broadly rounded, flattened near the beaks; beaks subcentral, nearer anterior end, approximate, excavated in front by a small, poorly defined lunule; anterior border sloping steeply, rounded below; surface marked by fine concentric lines over most of it, and by well-developed posterior plications extending from behind the beaks to the sharply bent postero-ventral margin. The interior features of the shell, as shown in one example, are lucinoid, and include well-developed lateral teeth and two cardinals in the left valve, between which there is a triangular pit; the anterior adductor muscle is rather long, extending below the median line of the valve. The interior of the valve is rough and irregular, with faint concentric undulations. The holotype of this species is a well-preserved rock mold, from which good casts can readily be made, showing the external features of the shell. It has the following dimensions: length, 53 mm.; height, 41 mm.; thickness of single valve, 9 mm. Another example of the same species shows the hinge, anterior adductor muscle scar, and the interior form of the shell. Three examples of this species, including the holotype, were obtained by Gabb from Alcatraz Island, Bay of San Francisco, and were among the "Numerous casts" of the "other bivalves" mentioned by him in his description of *Inoceramus ellioti* (1869a, p. 193), which came from the same place. These examples, apparently labelled by Gabb, were left with other material from the same place at the University of California.

ISOCARDIIDAE Gray

Clisocolus Gabb

Clisocolus indubitus Anderson, n. sp.

Shell small, circular in outline, moderately inflated; beaks sub-central, elevated, curving forward, approximate; hinge margin gently curved; external ligamental scar narrow; lower border of shell nearly circular, thin, not crenulated; surface smooth above, marked by concentric lines below, which become irregularly spaced near the lower margin.

This shell somewhat resembles *Clisocolus dubius* (Gabb) from the Upper Cre-

taceous (Senonian) beds of Texas Flat, near Folsom, but is more like that from Sucia Island, figured by White. The present species is somewhat more inflated than either form mentioned above, lacks the straight hinge line of the first, and has more prominent beaks than the latter. The holotype (Calif. Acad. Sci. type Coll.) was found at Locality 1353 (Calif. Acad. Sci.) in the Ono zone near the bridge on the Cottonwood Creek, Shasta County. Its stratigraphical position is near the base of the Horsetown group; it was found associated with *Neocraspedites aquila*, nov., and many other species characteristic of this zone. It has the following dimensions: length, 20 mm.; height, 25 mm.; thickness of both valves, 20 mm.; form sub-spherical. This is the oldest species of the genus found in the Cretaceous of the West Coast.

VENERIDAE Leach

Venus Linnaeus

Venus collinium Anderson, n. sp.

(Plate 1, figure 3; Plate 4, figure 8)

Shell of medium size, subcircular in outline, as broad as high, moderately inflated, test rather thick; cardinal margin gently rounded, the curve merging regularly to that of the rounded basal margin; lunule well defined, narrow and lanceolate; basal margin of shell denticulate within; beaks a little depressed; surface of shell marked only by coarse, concentric, somewhat irregular lines, without radial sculpture; hinge plate apparently bearing three cardinal teeth.

Three incomplete examples of this species were found by E. J. Broad in the Hamlin-Broad zone at Locality 113 (Calif. Acad. Sci.), 4 miles southwest of Ono, Shasta County. Of these, the holotype (Calif. Acad. Sci. type Coll.) measures: length, 39 mm.; height, 39 mm.; thickness of one valve, 11 mm. The other examples were smaller. The horizon from which these examples were obtained is in the upper part of the Paskenta group, about 500 feet beneath the lowest bed of the Horsetown group in the Cottonwood district Two other examples of the same species were found by G. D. Hanna at Locality 1691 (Calif. Acad. Sci.) near Clements ranch, eastern Trinity County. At its type locality the species was associated with *Polyptychites lecontei*, *Lytoceras aulaeum*, *Subastieria chanchelula*, and many other forms. At the Clements ranch it was found associated with *Periplomya reddingensis*, *Pholadomya allumbonata*, and various other species regarded as representing the upper part of the Paskenta group, from which came the holotype of *Crioceras latum* Gabb, reported from the Trinity River.

Venus corella Anderson, n. sp.

(Plate 4, figures 6, 7)

Shell small, cordiform, inflated; beaks rather high, prominent, incurved, and approximate; lunule distinct, impressed, semicircular in outline; hinge line nearly straight; base circular; surface marked by uniform radiating ribs and by faint concentric lines of growth; interior margin of the valves denticulated with interlocking denticles.

The holotype (Calif. Acad. Sci. type Coll.) was found at Locality 1346-A (Calif. Acad. Sci.) in the Buenaventura zone of the Hulen beds, on the west branch of Hulen Creek, a mile above its entrance into the North fork of the Cottonwood Creek. It was associated with *Puzosia buenaventura* nov., *Cheloniceras* sp., *Acanthoplites* sp., and *Douvilleiceras* cf. *mammillatum*. Its dimensions are: length, 11 mm.; height, 12 mm.; thickness of both valves, 11 mm.

The same species was found also at Locality 152 (Calif. Acad. Sci.) in the Perrin

zone, on the east branch of Hulen Creek, and therefore somewhat higher in the section.

TELLINIDAE Deshayes

Tellina Linnaeus

Tellina (Arcopagia) tehama Anderson, n. sp.

(Plate 7, figures 3, 3a)

Shell rather large, oval in outline, slightly inequilateral, apparently inequivalve; shell only moderately inflated, thickest in the area below the beaks; lower margin broadly rounded, curving broadly in front, somewhat narrowed and angular behind; beaks sub-central, a little behind the center; hinge as shown in the figure, with long laterals, the left valve bearing two cardinal teeth; surface of shell marked only by concentric growth lines; beaks small, curving slightly inward and forward. The holotype (Calif. Acad. Sci. type Coll.) measures as follows: length, 85 mm.; height, 62 mm.; thickness of left valve, 16 mm. The shell somewhat resembles *Arcopagia circinalis* d'Orbigny, from the upper Cretaceous of France, but it belongs to a lower horizon, probably Cenomanian. This example was obtained from the zone of *Pervinquieria*, n. sp. in the lowermost Chico group on the Middle fork of Cottonwood Creek, Shasta County. The same species has also been found in the uppermost beds of the Horsetown group, a few miles to the south, on Dry Creek, just beneath the basal beds of the Chico group, Tehama County.

CORBULIDAE Fleming

Corbula filosa Stanton

Corbula filosa STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 62, pl. 11, figs. 1, 2; near Stephenson's on Cold fork of Cottonwood Creek, Tehama County.

"Shell small, oval, convex; beaks rather prominent, a little in advance of the middle; cardinal margin sloping almost equally from the beaks in front and behind; anterior end regularly rounded and narrower than the posterior end, which is also rounded, but more prominent above than below; ventral margin forming a broad curve; surface marked by slender filiform concentric lines, with somewhat broader interspaces. Some examples show an ill-defined subangular umbonal ridge extending from the beaks to the postero-basal margin. Length of a large specimen, 19 mm.; height, 13 mm.; convexity of single valve, about 7 mm."

No other species of *Corbula* had previously been reported from the Lower Cretaceous of California.

The name of this species occurs without question as to its determination in the list given by Stanton from its type locality. The horizon is regarded as within the Paskenta group of the Shasta series; found also in the lowest beds of the Horsetown group near the bridge on the North fork of Cottonwood Creek.

SAXICAVIDAE Gray

Panope Ménard

Panope concentrica (Gabb)

Panopaea concentrica GABB, Paleont. Calif., vol. 1, 1864, p. 148, pl. 22, fig. 119; Cottonwood Creek, Shasta County; vol. 2, 1869, p. 236 (in part, not "*Homomya*" *concentrica*; Chico Group).

Gabb's original description is in part as follows:

"Shell subquadrate, about a third longer than wide; beaks small, about a third of the length from the anterior end; posterior cardinal line very slightly sloping;

basal margin usually regularly curved, sometimes nearly straight; ends gaping; posterior end widest, surface marked by rather large, irregular, concentric ribs."

The holotype of this species is in the Museum of Paleontology, University of California. Stewart gives the following measurements of this specimen: length, 52 mm.; height, 37 mm.; thickness of both valves, 26.4 mm.

Although Gabb does not mention the diagonal depression extending obliquely downward from the beak to the posterior basal border, it is shown in his figure and seems to be characteristic of the shell of this species. A slightly smaller example of the species was found in the uppermost beds of the Horsetown group at Locality 1344 (Calif. Acad. Sci.), at the site of old Horsetown, Shasta County.

It agrees in all respects with the description and figure given by Gabb, and has the following dimensions: length, 48 mm.; height at beak, 30 mm.; thickness of both valves below beak, 21 mm.

The oblique depression begins near the top of the beak and reaches the base at the posterior basal angle. Larger examples have been collected at the same place, where it is commonly associated with *Puzosia hoffmanni* (Gabb), *Beudanticeras brewerí* (Gabb), and *Sonneratia stantoni* Anderson.

Panope subaequilateralis Anderson, n. sp.

(Plate 3, figure 6)

Shell of medium size, oval in outline, nearly smooth; beaks a little in advance of the middle, incurved, approximate, low, rounded; dorsal margin sloping gently backward, slightly concave; anterior dorsal margin, sloping more steeply; anterior margin narrow, abrupt; posterior margin broader, gently rounded; surface marked by faint growth lines and also by weak undulations about the beaks; no oblique depression visible; ends narrowly gaping.

The holotype (Calif. Acad. Sci. type Coll.) was obtained at Locality 1344 (Calif. Acad. Sci.) at old Horsetown; height, 55 mm.; length, 86 mm.; thickness of left valve, 18 mm.

Panope shastacola Anderson, n. sp.

(Plate 3, figure 7)

Shell of medium size, quadrate in outline, short, nearly as high as long; beaks small, situated near anterior end, incurved, approximate; dorsal margin slightly concave; anterior margin steep, curving to rounded anterior border; surface marked by strong depression extending obliquely backward from the beak to the posterior basal angle.

The holotype (Calif. Acad. Sci. type Coll.) measures as follows: length, 58 mm.; height below beak, 48 mm.; thickness of both valves, 30 mm.

Four examples of this species were obtained at Loc. 1344 (Calif. Acad. Sci.) at old Horsetown, with *Beudanticeras brewerí*, *B. haydeni* (Gabb), and many other species. In outline and surface markings the species resembles *Panope mandibula* d'Orbigny, but the resemblance may be superficial and not actual.

PHOLADIDAE Fischer

Turnus Gabb

Turnus plenus Gabb

Turnus plenus GABB, Paleont. Calif., vol. 1, 1864, p. 146, pl. 22, fig. 116; North fork of Cottonwood Creek, Shasta County; vol. 2, 1869, p. 233—STEWART, Phila. Acad. Nat. Sci., Spec. Publ. no. 3, 1930, p. 296, pl. 4, fig. 3; Locality not known.

The "lectotype" (? holotype) of this species is in the Museum of Paleontology,

University of California. Stewart gives the following measurements: length (incomplete), 22 mm.; height (incomplete), 18 mm.; thickness of (left) valve, ca. 10 mm.; No. 31 459. Stewart also gives a photographic figure of another example, said to be congeneric with the holotype. The locality of discovery is not definitely given by Gabb. If Gabb's drawing is made from the "lectotype" it is somewhat defective, as stated by Stewart.

The anterior end is broadly rounded, although having an oblique truncation below the middle of the forward end; the posterior end is not rounded, as in Gabb's figure, but also shows truncation; shell probably gaping at both ends; beaks strongly incurved, the apex being sub-central, a little nearer the anterior end; shell marked by a deep umbonal groove extending from the apex downward and backward to the basal border, seen distinctly on the outer surface of the shell; behind this and diverging slightly from it, there is an internal rib, not seen on the surface; both groove and rib are deeply impressed in the cast of the shell, and between them there is a flat, tabular rib, as seen on the cast, extending from the apex to the base of the shell.

This species is also the genotype. It is distinctly a wood-borer, and is usually found in blocks of fossil wood buried in shales. The exact horizon of the holotype is not known, but a number of good examples of the species were found by the writer in a block of fossil wood, in the shales of the Bradley zone on the North fork of Cottonwood Creek; the largest had a length of 25 mm. The tubes and shells of wood-boring mollusks, including *Turnus plenus* Gabb, are found in nearly all parts of the Horsetown group in the Cottonwood district, but they are particularly abundant in its upper part, where many fragments of fossil wood also occur. Such shells are found only in fossil wood.

Turnus gregarius Anderson, n. sp.

(Plate 7, figure 7)

The shell of this species approaches the outward form of the preceding, but it is much smaller and relatively not so high as compared to its length, and it is more delicately sculptured than the genotype. The tubes are often found closely crowded together in blocks of fossil wood, the borings being transverse to the axis of the wood. In one such block 4 inches square, found in the Neptune zone, more than 400 distinct and nearly parallel tubes were estimated, the usual diameter being 5 to 7 mm. The tubes were formed of calcareous shell matter filled with very fine sediment, their usual length being 50 to 80 mm. At their interior terminations was a zone of shell and shell fragments. This and many other wood fragments are in the Museum of the California Academy of Sciences. Although many of the shells are partly exposed, none of them are sufficiently well preserved and exposed for satisfactory illustration. For this reason the figure here given is necessarily a composite, although made from a single colony of shells.

SCAPHOPODA

DENTALIIDAE Gray

Dentalium Linnaeus

Dentalium californicum Stanton

Dentalium californicum STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 62, pl. 12, fig. 3; Shelton's ranch, 5 miles north of Paskenta, western Tehama County.

"Shell slender, rather strongly curved; aperture and cross section nearly circular; surface marked by about eight small angular longitudinal costae, alternating with an equal number of fine lines.

"Length of type specimen, 7 mm.; greatest diameter, 1 mm. The largest specimen seen is 11 mm. long."

The name of this species is found in the list given by Stanton (1895, p. 18) from the locality a quarter of a mile northwest of Shelton's house, where it was found associated with *Aucella crassicollis*, *"Olcostephanus" mutabilis* Stanton, *"Hoplites" angulatus* Stanton, and other species belonging in the Paskenta group of the Shasta series. It is not confined to the Paskenta group, however, since it has also been found at Locality 1353 (Calif. Acad. Sci.) at the base of the Horsetown group on the Cottonwood Creek, near Ono, Shasta County.

GASTROPODA

PATELLIDAE Carpenter

Helcion Monfort

Helcion granulatus Stanton

Helcion granulatus STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 63, pl. 12, fig. 4; Cold fork of Cottonwood Creek, Tehama County, California.

"Shell depressed, conical, with the apex a little in advance of the middle and directed slightly forward; aperture elliptical; surface marked by numerous slightly wavy radiating costae, which become somewhat broader on the posterior portion, crossed by rather closely arranged, impressed concentric lines, becoming more distant near the margin of large specimens.

"The figured type measures 13 mm. in length, 9 mm. in breadth, and about 3 mm. in height."

The species is included in a list given by Stanton (1895, p. 14) from the type locality, near Stephenson's house, on the Cold fork of Cottonwood Creek, which list and locality have already been referred to the area and stratigraphic limits of the Paskenta group of the Shasta series. Stanton's account of the species is the only record of its occurrence.

ACMAEIDAE Dall

Anisomyon Meek and Hayden

Anisomyon meeki (Gabb)

Anisomyon Meekii GABB, Paleont. Calif., vol. 1, 1864, p. 142, pl. 21, fig. 105; North fork of Cottonwood Creek, Shasta County; vol. 2, 1869, p. 231, "Shasta Group," Cottonwood Creek—STEWART, Phila. Acad. Nat. Sci., Pr., vol. 78, 1926, p. 312.

"Shell elliptical, very thin; the width and length are about as 5 to 6; apex moderately elevated, small, nearly central; sides sloping nearly straight in all directions to the base. Surface (of cast) marked by numerous irregular concentric undulations, which do not always continue entirely around the shell; there are also marks which probably indicate a few faint radiating lines."

The holotype of this species is in the Museum of the Academy of Natural Sciences, Philadelphia. According to Stewart the shorter diameter is 21 mm.; height, about 6.5 mm.

The exact horizon in the Shasta series at which this species has been found is not yet definitely known, as Cottonwood Creek crosses the entire series.

PLEUROTOMARIIDAE d'Orbigny

Pleurotomaria Sowerby

Pleurotomaria californica Anderson, n. sp.

(Plate 9, figure 7)

Shell of medium size, spire not high, broader than high, with narrow but open perforation at base; sculpture consisting of fine spiral threads on the base and lower

part of the whorl; upper slope of the shell showing weaker spiral sculpture crossed obliquely by lines of growth inclined strongly backward; outer portion of body whorl angulated by two prominent ridges, giving the whorl a biangular appearance.

The holotype gives the following measurements: width of base, 43 mm.; height, of spire, 24 mm.; width of perforation, 21 mm. This specimen was found at Locality 1348 (Calif. Acad. Sci.), in the Argonaut zone on Alderson Creek about 2 miles south of Ono, Shasta County. It was found associated with *Gabbioceras wintunium*, nov.

The species recalls in its size and form, but not in sculpture, *Pleurotomaria skidegatensis* Whiteaves, from the east end of Maude Island (Queen Charlotte Islands), which appears to represent the Haida group of MacKenzie.

The species here described has some resemblance of *Pleurotomaria daghestanica* Anthula (1900, pl. 4, figs. 7a, 7b).

Fissurellidae Risso

Fissurella Bruguière

Fissurella bipunctata Stanton

Fissurella bipunctata Stanton, U. S. Geol. Surv., Bull. 133, 1895, p. 63, pl. 13, fig. 8; Cold fork of Cottonwood Creek, Tehama County.

"Shell small, elevated, conical, with the apex directed slightly forward and perforated; aperture subcircular; surface cancellated, the sculpture consisting of strong radiating ribs alternating with fine lines crossed in the interspaces between the ribs by stronger concentric lines, so that the interspaces when magnified have the appearance of radiating double rows of punctations.

"The aperture of the type specimen, the only one known, measures 4 mm. by 6 mm.; and its height is about 3.5 mm."

The appearance of this name in the list of species given by Stanton (1895, p. 14) from its type locality, associated with *Aucella crassicollis* and other species characteristic of the Paskenta group, is the best evidence of its proper horizon.

According to Stewart (1926, p. 313), the genus is probably *Emarginula*. Stanton's record of this species in the Shasta series is the only one known.

Euomphalidae de Koninck

Discohelix Dunker 1847

Note by G. D. Hanna

The generic name *Discohelix* was used by Dunker (1847, p. 132, pl. 18, fig. 11) for the species *Discohelix calculiformis* from the "Laiakalkstein am Heinberg bei Gottigen." This is a small species with a doubly concave shell about 16 mm. in diameter, the whorls square in cross section, with sharp dorsal and ventral carinae, exactly as in the species to be described from the Lower Cretaceous of the Cottonwood district. So nearly do the two forms resemble each other that this form might readily be taken for a miniature specimen of Dunker's species from the Triassic of Germany.

Many authors have commented upon the relationship of *Discohelix* and its allies, but references to only a few of them will suffice. Pilsbry (von Zittel, 1913, p. 528) limited the genus to doubly carinated, discoidal shells with a geologic range from Triassic to Oligocene, and included it in de Koninck's family Euomphalidae.

J. Brookes Knight (1934, p. 139–166) gives an excellent review of the Carboniferous genera. Some of the species resemble *Discohelix*, but the whorls seem rarely, if ever, to have a true rectangular section. The upper and lower sides, moreover, do not appear to be quite equally concave.

Gabb has described "*Discohelix*" *leana* from the "Chico" beds of Texas Flat,

Placer County, California; the shell is discoidal with smooth rounded whorls, almost circular in section, resembling the Carboniferous *Crassidorsa* Brown.

Stewart (1927, p. 314) has commented but little upon Gabb's species and its relationship, but concludes that it is not a *Discohelix*. Stoliczka (1868, p. 252) had long before placed the species in the genus *Cyclogyra* Wood, a group sometimes thought to have been founded upon forms of Foraminifera.

Dall (1892, p. 331) has discussed *Discohelix* at length and has proposed a new section, *Discosolis*, for the American forms. The genotype, *D. setifer* Dall (1892, pl. 19, fig. 1) is a heavily nodose shell, not equally biconvex above and below. If the other American forms, *D. rostella* Lea (Eocene), *D. nobilis* Verrill, and *D. lamillifera* Dall (recent), are sufficiently close to be included in *Discohelix*, then the species here described would much better be retained with typical *Discohelix*.

Wade (1926, p. 175) has described two new species from the Upper Cretaceous of Tennessee under the names *Pseudomalaxis ripleyana* and *P. amplificata*. In both forms the whorls are slightly asymmetric in section, and the spiral is not equally depressed above and below. It thus appears that the diagnosis of the genera included in Euomphalidae offers many difficulties. The desire on the part of some students to recognize geologic and geographic groups of species has produced a multiplicity of names, not all founded upon sound conchological criteria. Cossmann's revision has not yet met with general acceptance.

Discohelix planigyroides Hanna, n. sp.

(Plate 27, figures 5, 5a)

"Shell discoidal, equally concave above and below, consisting of about five whorls, square in cross section; whorls with sharp carinae at each angle, and with the surface between the upper two and the lower two slightly concave; last half of last whorl widely departing from the coil, in the holotype, and tending to do so in other examples. Greatest diameter, 8.6 mm.; smallest diameter, 5.1 mm.; altitude of body-whorl, about 1 mm."

The holotype (Calif. Acad. Sci. type Coll.) was found on the North fork of Cottonwood Creek, Shasta County, about a mile above the diversion dam and a mile or more below the big bend of the creek. The holotype and other specimens are represented by external molds of the shells, showing no distortion, but from which it is not possible to determine the direction of the growth lines.

The species is abundant in the upper part of the Paskenta group of the Shasta series about 400 feet above the local base of the group, and about 600 feet beneath the Hamlin-Broad zone of Locality 113 (Calif. Acad. Sci.), containing *Thurmannia jupiter*, nov., *Lytoceras aulaeum* nov., and *Acroteuthis kernensis* nov. The examples obtained were associated with various fossil Mollusca, including a small species of *Trigonia*, *Nemodon* cf. *textirina* (Stanton), *Pecten californicus* Gabb, and *Turritella* sp.

The species has also been found in strata about 300 feet above the Hamlin-Broad zone, associated with *Plicatula variata*, *Phylloceras occidentalis* nov., and *Neocraspedites*.

The horizon of the type locality is clearly within the Valanginian of European chronology. The discovery of this interesting form in the lowest group of the California Cretaceous warrants the preceding notes on its generic and family relationship by Dr. Hanna.

TURBINIDAE Adams

Among the littoral molluscan species found in the lower beds of the Shasta series in the Great Valley of California there are many members of this family. None

have yet appeared in the immediately underlying Knoxville (Upper Jurassic) beds from which the stock might supposedly have been derived. Stanton has described five or six species of the genus *Turbo* alone.

Turbo Linnaeus

Turbo morganensis Stanton

Turbo morganensis STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 66, pl. 12, fig. 13; Morgan Valley, Lake County.

This is the most ornate form of the several species of this genus that have yet been found in the Lower Cretaceous of California. The original description is in part as follows:

"Surface of the spire marked by two strong nodose revolving ridges that give the whorls a biangular appearance, crossed on the first two whorls by small transverse lines connecting the nodes; body whorl in front of the two ridges bearing four or five somewhat less prominent distant revolving lines."

The upper portion of the whorl is described and shown in the figure as nearly smooth.

The holotype of this species is one of four examples found in Morgan Valley, a mile northwest of the Palmer ranch, on the road from Lower Lake to Knoxville. The species is here associated with *Pecten complexicosta* Gabb, *Astarte trapezoidalis* Stanton, and *Atresius liratus* Gabb.

The horizon represented by these several species is low in the Paskenta group, in an area in which these beds make a wide overlap upon pre-Cretaceous formations.

Turbo festivus Anderson, n. sp.

(Plate 10, figure 5)

Shell of medium size, subglobose, nacreous in texture; whorls few, angulated; spire moderately high, conical; imperforate, aperture subcircular, inner lip thickened, outer lip thin.

This species may perhaps belong in the section "Laeviturbo" of Cossmann, but this cannot be determined at present. The whorls are angulated, with two ridge-like threads on the whorls, one near, but above the suture, the other higher on the whorl, at the outer border of the upper slope. There is a slight appearance of beading on the latter angle on one of the six examples obtained.

The holotype (Calif. Acad. Sci. type Coll.) measures: height, 25 mm.; greatest width, 17 mm. All the examples were found at Locality 1353 (Calif. Acad. Sci.), near the bridge on the North fork of Cottonwood Creek at Ono, in the lowest fossil zone of the Horsetown group.

All the species described by Stanton are believed to have been found in the Paskenta group in areas south of the delta axis; the appearance of the present species in the Horsetown group in the Cottonwood district aids only in indicating the relationship of the groups.

Turbo trilineatus Stanton

Turbo trilineatus STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 65, pl. 12, fig. 12; 3 miles south of Lowry's, Tehama County.

This species is described as follows:

"Shell small, obliquely ovate, consisting of about four rapidly increasing convex whorls; surface ornamented by three elevated, equidistant revolving lines that are visible on the spire, by seven or eight fainter and more closely arranged revolving

Turbo wilburensis STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 65, pl. 12, fig. 15; in the white limestone near Wilbur Springs, Colusa County.

The concise description of Stanton is:

"Shell of medium size, elongate ovate, consisting of five or six rounded whorls; suture linear, impressed; surface ornamented with small, elevated, slightly nodose revolving lines, of which there are about twenty on the body whorl, and about nine are visible on the spire."

Height of largest specimen, which is incomplete at the apex, 34 mm.; greatest breadth, 25 mm

At the type locality near Wilbur Springs, this species is associated with *Rhynchonella whitneyi*, *Modiolus major* Gabb, *Pecten complexicosta*, *Lucina colusaensis*, and other species of *Turbo*. Most of the species are also found at other localities near the base of the Paskenta group.

"Turbo" humerosus Stanton

Turbo ? humerosus STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 67, pl. 12, figs. 10, 11; 3 miles south of Lowry's, Tehama County.

This shell is distinguished from preceding species referred to the genus *Turbo* by angulated ridge on the upper part of the body whorl, and broad ovate, rather than circular, aperture. It appears to be only doubtfully included in *Turbinidae*, but to be more correctly included in the family to which *Amberelya* belongs.

Although its locality is given as 3 miles north of Lowry's, the species is included in a list (Stanton, 1895, p. 17) from a locality 3 miles south of this place, which seems to be the more probable position. It is said to occur also in the white limestone near Wilbur Springs, Colusa County. Both localities are in the Paskenta group of the Shasta series.

Atresius Gabb

Atresius liratus Gabb

Atresius liratus GABB, Paleont. Calif., vol. 2, 1869, p. 169, 227, pl. 28, fig. 50; "Shasta Group," Sulphur Springs, Colusa County—STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 68, 69; locality as above, and one mile northeast of the Palmer ranch, Morgan Valley, Lake County, "upper part of the Knoxville"—STEWART, Phila. Acad. Nat. Sci., Pr., vol. 78, 1926, p. 426, pl. 23, fig. 3; holotype in the Museum of Comparative Zoology, Harvard University, figured.

This species is common in the white limestones of the Paskenta group in the Coast Ranges south of Shasta County. It is recorded from various places, as near Wilbur Springs, Colusa County; Morgan Valley, Lake County; west border of Berryessa Valley, Napa County; and in the Berkeley Hills, north border of Berkeley. In nearly all cases it has been found associated with *Aucella* of the types found in the Paskenta group. It may accordingly be regarded as an index fossil of this group.

NERITIDAE Lamarck

Nerita Linnaeus

Nerita deformis Gabb

Nerita deformis GABB, Paleont. Calif., vol. 1, 1864, p. 137, pl. 21, fig. 96; North fork of Cottonwood Creek, Shasta County—STEWART, Phila. Acad. Nat. Sci., Pr., vol. 78, 1926, p. 319; locality as above.

The holotype of this species is in the Museum of Paleontology, University of California. According to Stewart it is "related to the *Turbinidae*."

Search has been made for the species in the Shasta series of the Cottonwood district, but thus far without results, and there is no other record of its occurrence.

PYRAMIDELLIDAE Gray

Hypsipleura Koken

Hypsipleura gregaria Stanton

Hypsipleura gregaria STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 70, pl. 13, figs. 1, 2; upper part of the "Knoxville beds," on the Shelton ranch, 5 miles north of Paskenta, Tehama County.

This species is briefly but concisely described by Stanton as follows:

"Shell very small, rather slender, elongate, composed of about seven slightly convex whorls; suture impressed, linear; sculpture consisting of ten or twelve transverse costae on each whorl extending entirely across the upper whorls of the spire, but shortened to mere tubercules forming a row on the upper margin of the last two or three whorls, aperture obliquely ovate with a thin, sharp outer lip."

Height of an average specimen, 3 mm.; greatest breadth, a little more than 1 mm.

Said to occur with *Aucella crassicollis*, its stratigraphic position is that of this latter form, which here and elsewhere has been regarded as near the middle or in the upper part of the Paskenta group.

Liocium Gabb

Liocium punctatum Gabb

Liocium punctatum GABB, Paleont. Calif., vol. 2, 1869, p. 174, pl. 28, fig. 59; "Shasta Group, south of the road from Colusa to the Hot Sulphur Springs, in the first range of foothills, Colusa County"—STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 19; "abundant" in "upper Horsetown" beds—STEWART, Phila. Acad. Nat. Sci., Pr., vol. 78, 1928, p. 319, pl. 24, fig. 6; Gabb's holotype figured.

Stanton's record of the occurrence of this species in beds of "upper Horsetown" age is the only reason for including it in the fauna of the Shasta series. If Gabb's statement as to the locality of its discovery is to be taken literally, it can hardly be older than the upper Turonian beds of the Chico series.

NATICIDAE Forbes

Ampullina Lamarck

Ampullina avellana (Gabb)

Lunatia avellana GABB, Paleont. Calif., vol. 1, 1864, p. 105, pl. 19, fig. 80; North fork of Cottonwood Creek, Shasta County; vol. 2, 1869, p. 222; locality as above.
Ampullina avellana (Gabb), STEWART, Phila. Acad. Nat. Sci., Pr., vol. 78, 1928, p. 333, pl. 21, fig. 9; locality as above.

From seven specimens in the Museum of the Academy of Natural Sciences of Philadelphia, Stewart has selected and figured a proposed lectotype, giving its horizon

as indicated by Gabb. The species has since been found abundantly in widely separated zones on the Cottonwood Creek, Shasta County, as follows:

a. Loc. 1353 (Calif. Acad. Sci.) in the lower beds of the Horsetown group, near Ono.

b. Loc. 1659 (Calif. Acad. Sci.) in the upper beds of the Horsetown group, Hulen Creek.

c. Loc. 1292 (Calif. Acad. Sci.) in the basal beds of the Chico series, Cottonwood Creek.

The stratigraphic range of the species is therefore throughout the Horsetown group, extending into the lower beds of the Chico series.

TURRITELLIDAE Gray

Glauconia Giebel

Glauconia hesperia Anderson, n. sp.

(Plate 9, figures 8, 9)

Shell small, spire tapering rapidly; whorls about eight or nine, each bordered above by a distinct spiral ridge situated beneath the suture; sides of whorl slightly concave; surface marked by traces of transverse, vertical ribs and by fine revolving lines, best seen in the mold; final whorl bordered by spiral ridges at top and bottom; base terminating abruptly, bearing a short canal, apparently not marked by spiral lines.

The holotype (Calif. Acad. Sci. type Coll.) was found at Locality 152 (Calif. Acad. Sci.) in the Perrin zone of the Hulen beds, associated with *Phylloceras theresae* nov., *Sonneratia taffi* nov., and *Douvilleiceras mammillatum* var. It affords the following measurements: height of spire (incomplete), 18 mm.; width of last whorl, 11 mm.; width at top (where broken), 6 mm. Only a single example of this species has been found, and this record of its occurrence in the Shasta series is the only one yet made.

NERINEIDAE Zittel

Nerinea Defrance

Nerinea archimedis Anderson, n. sp.

(Plate 9, figure 1)

Shell high, turreted, slender, tapering to a thin point; base abrupt, canal short, recurved; many whorls (28 on holotype), bordered above by a revolving ridge, just beneath the suture, giving the whorls a concave appearance; on the upper half of the spire a low median spiral ridge is visible, which is lost on the lower whorls; all revolving ridges beaded on the younger whorls, nearly smooth on the older; aperture subquadrate, bordered in front by an angular plication, and on the outer lip by a sinus forming a narrow posterior notch; columella of last whorl bearing a plication, not shown on columella above.

The holotype (Calif. Acad. Sci. type Coll.) measures: height of spire, 51 mm.; width of base, 12 mm.; last whorl somewhat flat. The holotype and four fragmentary examples were obtained at Locality 1353 (Calif. Acad. Sci.), near the bridge on the North fork of Cottonwood Creek, near Ono, Shasta County. It represents the Ono zone near the base of the Horsetown group of the Shasta series. It was found with *Tessarolax bicarinata* (Gabb), *Inoceramus colonicus* nov., and *Neocraspedites aquila* nov.

Whiteaves has figured and described *Nerinea maudensis* from the east end of

Maude Island (Queen Charlotte Islands), from beds that have been thought to belong in the Haida group, which apparently is much younger than those at Ono.

Nerinea sp. undet.

(Plate 9, figures 2, 3)

Shell small, spire short, relatively thick, turreted as in the preceding species, although sloping more rapidly to the apex; basal part not known. This species occurs with the preceding at Locality 1353 (Calif. Acad. Sci.) in the Ono zone, near the base of the Horsetown group on the Cottonwood Creek, Shasta County. Because of the rarity of the genus in the Cretaceous of California, this form is here recorded with the preceding.

"Nerinea" dispar Gabb

Nerinea dispar GABB, Paleont. Calif., vol. 1, 1864, p. 113, pl. 19, figs. 66, 66a; North fork of Cottonwood Creek, Shasta County; vol. 2, 1869, p. 231, "Shasta Group." Cottonwood Creek—STEWART, Phila. Acad. Nat. Sci., Pr., vol. 78, 1926, p. 322.

This species seems not to have been recognized by later writers, and there is no record of its occurrence in the Shasta series other than that given by Gabb. The holotype is in the Museum of Paleontology, University of California. Stewart gives its dimensions as follows: length (incomplete), 55 mm.; width, 13.5 mm.

According to Stewart (1926, p. 322) it is "related to *'Clavicala' clementina* (d'Orbigny) from the Cretaceous (Albian) of Europe."

A similar form, although much smaller than Gabb's species, has been found in the lower Chico beds of Middle fork of Cottonwood Creek.

CERITHIIDAE Menke

Cerithium strigosum Stanton

Cerithium strigosum STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 71, pl. 13, fig. 7; Shelton's ranch, 5 miles north of Paskenta, Tehama County.

"Shell small, slender, consisting of nine or ten rounded whorls, surface ornamented by narrow, elevated, transverse costae and by revolving lines. There are eight costae on each whorl, so arranged that they form continuous varices the full length of the shell. Four of the revolving lines are visible on the spire.

"Height, 6 mm.; greatest breadth, 2 mm."

The list of species (Stanton, 1895, p. 18) containing this form contains also *Aucella crassicollis*, *"Olcostephanus" mutabilis* Stanton, *"Hoplites" angulatus*, and other species characteristic of the Paskenta group.

Potamides diadema Gabb

Potamides diadema GABB, Paleont. Calif., vol. 1, 1864, p. 130, 227, pl. 20, fig. 85; North fork of Cottonwood Creek, Shasta County; vol. 2, 1869, p. 227; "Shasta Group," Cottonwood Creek—STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 18; lower Horsetown, North fork of Cottonwood Creek—STEWART, Phila. Acad. Nat. Sci., Pr., vol. 78, 1926, p. 356; Locality and horizon as above.

This species is abundant in the lower beds of the Horsetown group of the Shasta series.

It has been found abundantly in the beds exposed near the bridge at Ono (Locality 1353, Calif. Acad. Sci.), where it is associated with *Neocraspedites aquila* nov., *Acroteuthis kernensis* nov., and *Inoceramus colonicus* nov.

APORRHAIDAE Philippi

Anchura Conrad

Anchura biangulata Anderson, n. sp.

(Plate 9, figures 4, 5, 6)

Aporrhais angulata GABB (in part), Paleont. Calif., vol. 1, 1864, p. 128, (not pl. 20, fig. 84; Bull's Head Point).
Anchura ? angulata (Gabb), STEWART, (in part), Phila. Acad. Nat. Sci., Pr., vol. 78, 1926, p. 361 (not pl. 22, figs. 4, 5).

In his description of "*Aporrhais*" *angulata* (1864, p. 128), Gabb stated that:

"Mr. Brewer collected three specimens at Huling Creek, near the Cottonwood Creek locality, resembling this species in surface ornamentation, and in the shape of the upper whorls, but in which the last whorl was distinctly bicarinate."

This locality has been unsuccessfully searched for Gabb's species, although a number of distinctly bicarinate examples of a larger species have been found which in other respects agree with the form indicated by Gabb. The angular ridges on the body whorl completely encircle it, the more prominent upper ridge passing outward into the wing, or outer lip expansion; the lower one becomes lost. The whorls of the spire are not rounded, as in *Anchura angulata*, but for the most part are angular in section parallel to the axis; these whorls bear 8 to 10 vertical ribs, or varices, which are crossed by numerous revolving threads.

The holotype (Calif. Acad. Sci. type Coll.) is incomplete as to spire and canal, and measures as follows: height, 57 mm.; width of body whorl, 22 mm.; aperture distinctly triangular in outline. The wing, as shown in the paratype, (Calif. Acad. Sci. type Coll.), rises obliquely from the upper part of the aperture in a broad curve, and at its outer end forms a distinct expansion. This expansion rises into an acuminate point not quite parallel to the axis of the spire and terminates below in a distinct spur. The canal is long and nearly straight; height of paratype (incomplete), 57 mm.; width of body whorl, 22 mm.; outer margin of wing, from end of spur to terminus of upper point, directed slightly backward. This species has been found not only in the Perrin zone of the Hulen beds, on Hulen Creek (probably Brewer's locality), but also in the basal beds of the overlying Chico series on Cottonwood Creek. The holotype and also the paratype came from the latter horizon, at Locality 1346-A (Calif. Acad. Sci.). Most of the examples found here were firmly cemented in the matrix of a conglomerate and could not be extracted without breaking. *Anchura biangulata*, nov. appears to have survived the epoch of disturbance between the Shasta and Chico series, whereas *Anchura angulata* (Gabb) has not been found in the Shasta series and may be confined to the later group.

Tessarolax Gabb 1864

Tessarolax bicarinata (Gabb)

Helicaulax bicarinata GABB, Paleont. Calif., vol. 2, 1869, p. 166, pl. 27, fig. 47; "Shasta Group," Cottonwood Creek, Shasta County, (not *Rostellaria bicarinata* Deshayes)—STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 72; Horsetown beds, Cottonwood Creek, Shasta County.
Tessarolax bicarinata (Gabb), STEWART, Phila. Acad. Nat. Sci., Pr., vol. 78, 1926, p. 364, pl. 23, fig. 6; holotype figured.

Stanton (1895, p. 72) wrote that

"The whorls on the spire are distinctly angular, instead of plane, as shown in Gabb's figure."

Stewart notes that "on the body whorl the anterior angle, at least, is crenulated". He gives the following measurements for the holotype: height (incomplete), 20 mm.; smallest diameter of body whorl (crushed), 12 mm.

According to Stewart (1926, p. 365), "A specimen in the U. S. National Museum collected by Dr. Stanton (Locality 1092), one-half to three-fourths of a mile east of Wilcox's ranch, on the road from Lowrey's to Paskenta, . . . is probably this species."

This locality east of Wilcox's ranch is in the lower beds of the Horsetown group, and the record of this species here accords with the writer's findings.

This species has been obtained at Locality 1353 (Calif. Acad. Sci.), near the bridge on the Cottonwood Creek at Ono, Shasta County; although the example is too much crushed for illustration, it is easily recognized. It affords the following measurements: height of spire (incomplete), 20 mm.; width of whorl, 20 mm.

Its horizon is that of the Ono zone, near the base of the Horsetown group of the Shasta series.

VOLUTIDAE Gray

Volutoderma Gabb

Volutoderma mitraeformis (Gabb)

Cardiera mitraeformis GABB, Paleont. Calif., vol. 2, 1869, p. 153, pl. 26, fig. 32; "Shasta Group," Colusa County, near the Hot Sulphur Springs"—STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 19; listed with others from the above locality.

Volutoderma mitraeformis (Gabb), STEWART, Phila. Acad. Nat. Sci., Pr., vol. 78, 1926, p. 410; quotes Gabb as to locality and horizon.

The locality and horizon of this species have apparently been misunderstood. Although the species is mentioned by Stanton, together with three others as "possibly belonging in the Knoxville fauna," he omitted them until something more is learned of their stratigraphic position.

This list includes *Paleotractus crassus*, *Ringinella polita*, and *Liocium punctatum* Gabb. From Gabb's statements it appears that all of them came from the same locality, which he has described variously, but which can only be correctly understood as near the outer border of the foothills, east of Wilbur Springs; therefore, the horizon of all of them should be the middle part of the Chico series. The presence of *Atresius liratus* Gabb, a well-known Shasta species, in Gabb's list may be regarded as accidental, since it is not an associate of the other species in other places, or probably in any place.

Although species of *Volutoderma* are common in the Upper Cretaceous of California and Oregon, none have yet been authentically recorded from the Shasta series, and its alleged presence there should be accepted with reserve.

ACTEONIDAE d'Orbigny

Tornatellaea Conrad, 1860

Tornatellaea impressa (Gabb)

Actaeon (*Tornatella*) *impressus* GABB, Paleont. Calif., vol. 1, 1864, p. 142, pl. 21, fig. 106; vol. 2, 1869, p. 232; "Shasta Group," North fork of Cottonwood Creek, Shasta County—STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 18; included in a list of Horsetown species from near Wilcox's ranch.

Tornatellaea impressa (Gabb), STEWART, Phila. Acad. Nat. Sci., Pr., vol. 78, 1926, p. 434, pl. 24, figs. 7, 8; lectotype figured.

Stewart gives the following dimensions for the lectotype: height, 11 mm.; width, 6 mm. As far as information goes at present this species has been found only in the Horsetown group in Shasta County. Stanton records it from the lower Horsetown beds near Ono, perhaps in the Ono zone.

Acteon politus (Gabb)

Ringinella polita GABB, Paleont. Calif., vol. 2, 1869, p. 174, pl. 28, fig. 60; "Shasta Group," Colusa County—STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 19; age later than the Paskenta group suggested—ANDERSON, Calif. Acad. Sci., Pr., 3d ser., vol. 2, 1902, p. 41; species included in Horsetown group.

Acteon politus (Gabb) STEWART, Phila. Acad. Nat. Sci., Pr., vol. 78, 1926, p. 431, pl. 24, figs. 18, 19; supposed holotype.

Gabb's record as to the locality at which the holotype was obtained is the only known record. He states (Gabb, 1869a, p. 175), that this species was found with *Liocium punctatum* "south of the road from Colusa to the Hot Sulphur Springs, in the first range of foothills, Colusa County." If this statement is taken literally the species and its associates can hardly be older than the middle part of the Chico series. Similar forms have been found in the Chico beds of the Rogue River Valley, in southern Oregon.

Acteonina calafia Stewart

?*Acteonina pupoides* GABB, Paleont. Calif., vol. 1, 1864, p. 113, pl. 19, fig. 67; North fork of Cottonwood Creek, Shasta County; vol. 2, 1869, p. 173, pl. 28, fig. 57, "Shasta Group," Cottonwood Creek.

Acteonina calafia STEWART, Phila. Acad. Nat. Sci., vol. 78, 1926, p. 432, pl. 21, fig. 12.

Stewart states that Gabb's holotype in the Museum of Paleontology is a fragment, and the "name a homonym," and proposes as the holotype of his own species the specimen described and figured by Gabb (1869a, p. 173, pl. 28, fig. 57). Gabb states that the horizon of this species is within the "Shasta Group," but its occurrence in this group rests only upon his record.

Acteonella oviformis Gabb

Acteonella oviformis GABB, Paleont. Calif., vol. 2, 1869, p. 173, 232, pl. 28, fig. 58; "Chico Group," Cottonwood Creek, Shasta County—STEWART, Phila. Acad. Nat. Sci., Pr., vol. 78, 1926, p. 432; locality and horizon as given by Gabb.

This species is abundant in the Chico series at many localities in California and in southern Oregon, and has usually been regarded as belonging exclusively to this series, its usual horizon being in the Turonian or Cenomanian portion. A single example of the species has recently been obtained from the lower beds of the Horsetown group at Locality 1353 (Calif. Acad. Sci.) near the bridge on the North fork of Cottonwood Creek, at Ono. Its range, therefore, is throughout the Horsetown group and the lower part of the Chico series.

Paladmete Gardner 1916

Paladmete perforata (Gabb)

Neptunea perforata GABB, Paleont. Calif., vol. 1, 1864, p. 89, pl. 18, fig. 39; North fork of Cottonwood Creek, Shasta County.

Eripachya perforata GABB, Paleont. Calif., vol. 2, 1869, p. 49; "Shasta Group," Cottonwood Creek.

Paladmete perforata (Gabb), STEWART, Phila. Acad. Nat. Sci., Pr., vol. 78, 1926, p. 424, pl. 22, fig. 8; lectotype, from the collection of the University of California, figured.

The figure and description given by Gabb leaves much to be desired. According to Stewart this species may also include *Paladmete hoffmanni* (Gabb) and this view seems plausible. Both are from the same locality, as given by Gabb. As the North fork of the Cottonwood Creek crosses the whole of the Horsetown group and a considerable part of the Chico series, the horizon of the species yet remains in doubt.

CEPHALOPODA

The oldest cephalopod stocks known in the Cretaceous sequences in California and Oregon include both ammonoids and belemnoids, but their origins are yet unknown. There is little, if any, evidence that they are derived from stocks found in the underlying Knoxville series, although some of them may later be traced to such source.

Among ammonoids, forms of *Phylloceras*, *Lytoceras*, *Bochianites*, and berriasellids are found in the lowest group of the Cretaceous deposits, but they can hardly be shown to have descended from such stocks in the older series, although these are near at hand, contain some similar stocks, and apparently in part are in sequencial contact with them. The cephalopod groups in the Knoxville and Shasta series are specifically distinct, although both contain the genera mentioned above.

Forms of *Phylloceras* occur in the upper beds of the Knoxville, and in the lowest beds of the Shasta series, but they appear to represent different species—one Jurassic and the other Cretaceous. Furthermore, successive types of *Phylloceras* appear in the Shasta series at different levels, although not of a single lineage, and none of them can be traced to local Tithonian sources, and most of them are of short duration.

Forms of *Lytoceras* are known in the Tithonian of the Knoxville, and the genus appears in the earliest beds of the Shasta series. Different types of Lytoceratids also appear at intervals in the latter series, particularly in the Horsetown group; none of these can be definitely traced to local sources, and their nearest allies are found only in distant regions, as southwestern Asia or Europe. It would seem that "waves" of Lytoceratids (possibly immigrations) appear at intervals in the Great Valley embayments, from unknown sources and by undetermined routes.

Berriasellids, near to *Berriasella calisto* (d'Orbigny), occur in the upper part of the Knoxville, but they have not been found in the lower beds of the Shasta series. The oldest hoplitids of the Shasta series seem referable to *Neocomites* or *Thurmannia*. Species of *Berriasella* appear in higher beds of the series, but they are not closely related to those of the Knoxville, and they soon disappear, leaving no known descendants. This is true also of other generic groups. Forms of *Spiticeras* are found in both series.

Among belemnoids there are numerous species, and genera, found in the upper part of the Knoxville, and also in the lower beds of the Shasta series, but their genetic relations are not close. The type so far found in the two series do not belong to the same stocks. Species of *Cylindroteuthis* Bayle and Zeiler are abundant in the Tithonian, but none are known in the later series. On the contrary, various species referable to *Acroteuthis* Stolley, to *Belemnopsis* Bayle, and to *Belemnoteuthis* Pearce are found in the Shasta series, ranging from Valanginian to Gargasian, but none have been found in the Knoxville series.

From these observations there is little evidence that the cephalopod faunas of the Shasta series have descended from local sources, or that their progenitors are to be found in the Knoxville series, although they were near at hand and seemingly in position to have been the source of Cretaceous stocks. To what causes may we look for explanation of these striking facts? In the earlier part of this paper possible sources of cephalopod stocks in remote regions have been suggested, especially for

those in the Horsetown group, which are clearly different from any known in the Knoxville series, or even in the older beds of the Shasta series, and which have their nearest allies in trans-Pacific regions.

NAUTILOIDEA

NAUTILIDAE Owen

Nautilus Linnaeus

Nautilus gabbi Anderson

(Plate 10, figure 1)

Nautilus texanus (?) GABB, Paleont. Calif., vol. 1, 1864, p. 59, pl. 9, figs. 3, 3a; Alderson Gulch, Shasta County (not *Nautilus texanus* Shumard, Texas Cretaceous).
Nautilus gabbi ANDERSON, Calif. Acad. Sci., Pr., 3d ser., vol. 2, 1902, p. 77, Cottonwood Creek, Shasta County.

This species, doubtfully referred by Gabb to a Texas form, is fairly common in the upper part of the Horsetown group in the Cottonwood district. Most examples seem to agree with Gabb's figures, and one may accept his statement as to the type locality. A large cast of the species still retaining portions of the shell was found on the west branch of Hulen Creek at Locality 1668 (Calif. Acad. Sci.). It has a diameter of at least 150 mm., and a thickness of 70 mm. On parts of the body-chamber the shell shows the strong backward bend of the costal lines near the periphery of the whorl, as shown in Gabb's figure. This specimen was found in the Perrin zone, associated with *Cleoniceras modeste*, nov. and *Acanthoplites perrini*, nov. in the upper part of the Horsetown group. The septa show only a slight backward bend on the periphery; the umbilicus is small, but not closed; the siphonal tube is low, about 5 mm. above the base of the aperture—that is, above the top of the preceding whorl. A smaller but incomplete example of the same species is in the collection of Stanford University; it was found by L. M. Clark on the Julian ranch, 8 miles southeast of Lompoc, Santa Barbara County.

Nautilus charlottensis Whiteaves

Nautilus suciensis WHITEAVES, Mes. Foss., vol. 1, pt. 3, 1884, p. 197, pl. 21, Welcome Point, Skidegate Inlet, Queen Charlotte Islands (not Pl. 11, figs. 1, 1a; Sucia Island).
Nautilus (*Cymatoceras*) *charlottensis* WHITEAVES, Mes. Foss., pt. 4, 1900, p. 289; Welcome Point, Maple Island—ANDERSON, Calif. Acad. Sci., Pr., 3d ser., vol. 2, 1902, p. 78; Horsetown, Shasta County.

In the collections of Cretaceous fossils at Stanford University there is a large fragmentary specimen of this species found by the writer in a hard sandstone bed at old Horsetown, in the lowest bed exposed there. Another example of the same species has since been found near the mouth of Hulen Creek, encased in a boulder and buried in a conglomerate of the lower Chico beds. It has been transported from an older zone to this conglomerate bed. Both examples agree well with the figure and description given by Whiteaves for those from Queen Charlotte Islands. In the California Academy of Sciences are two fragmentary but well-preserved specimens of the species found by R. M. Kleinpell and E. Wayne Galliher on the north shore of Bearskin Bay, Graham Island, and donated to the Academy of Sciences. The California specimens differ in no important respects from these, although they are somewhat larger and possibly a little more inflated. The species is perhaps related to *Nautilus gabbi*, although it is more robust and occurs at a higher level in the sequence.

Nautilus averilli Anderson, n. sp.

(Plate 10, figure 2)

Mature shell large, sub-globose; umbilicus nearly closed; section of whorl broader than high; septal sutures simple, curving normally forward above the umbilical border and slightly backward near and upon the ventral surface; surface of holotype retaining little of the shell, showing only faint growth lines rising vertically on the lower half of the whorl but curving sharply backward on the upper part of the side, and forming a sharply rounded sinus in the ventral zone.

The holotype (Calif. Acad. Sci. type Coll.) is unlike any other species described from the West Coast. It is an immature, although well-preserved, shell having the following dimensions: maximum diameter, 72 mm.; width of umbilicus, 3 mm.; height of whorl, 40 mm.; width of whorl, 48 mm. A fragment of a larger example, obtained from the same bed, shows a maximum diameter of 110 mm. and a thickness proportional to that of the holotype. The holotype was found by Chas. V. Averill at Locality 1347 (Calif. Acad. Sci.), in the Barr zone, near the middle of the Horsetown group, 5 miles south of Ono, Shasta County. It was associated with *Acroteuthis aboriginalis* nov., *Parahoplitoides* sp., *Gabbioceras wintunium* nov., *Cheloniceras* sp., and *Syncyclonema californica* (Gabb). This is the earliest species of *Nautilus* yet recorded from the Cretaceous of the West Coast.

AMMONOIDEA

Phylloceratidae Zittel

Phylloceras Suess

Phylloceras occidentale Anderson, n. sp.

(Plate 12, figures 1, 2)

No complete example of this species has yet been obtained, although four imperfect specimens in the California Academy of Sciences seem to belong to it. They were found in three different zones, the lowest in the upper beds of the Paskenta group, the next in the lowest beds of the Horsetown group, and the other in the Barr zone of the latter.

The last example is the holotype (Calif. Acad. Sci. type Coll.); it is wholly septate, containing no part of the body-chamber. The shell is roundly inflated, angustumbilicate, deeply involute and distinctly costate. The shell increases rapidly in section, which is broadly ovate, the greatest thickness being a little below the ventral border. Between the broad costae are broader interspaces, about 27 to the whorl. Most of the ribs arise near the umbilical border, although some secondary ribs arise near the middle of the sides. All the ribs are much reduced in strength in crossing the abdomen. The primary ribs are inclined rather strongly forward near the umbilicus, but ascend on the sides nearly vertically and show a slight forward curve on the ventral zone. The umbilicus, quite narrow at bottom, expands into a broad funnel-form depression, the walls sloping upward from the center. The species has much resemblance to *Phylloceras infundibulum* d'Orbigny, from the lower Neocomian (lower Barremian or upper Hauterivian) of western Europe, but it is thicker in form and has fewer and more widely spaced ribs. The holotype (Calif. Acad. Sci. type Coll.) has the following dimensions: greatest diameter, 48 mm.; diameter of umbilicus, 2 mm.; height of whorl, 18 mm.; width of whorl, 23.5 mm.; umbilical ratio, .042:1.

The septa have the form and character of those of *Phylloceras rouyanum* d'Or-

bigny, as illustrated by Kilian (1907–1910, pl. 6), to which it seems to be nearly related.

The holotype of the species was found at Locality 1347 (Calif. Acad. Sci.) east of Mitchell Creek in the Barr zone; it was associated with *Acroteuthis aboriginalis*, nov. and *Gabbioceras angulatum* Anderson.

Possible successors of this species appear in the upper beds of the Horsetown group on Hulen Creek, and at old Horsetown on Clear Creek. *Phylloceras theresae* occurs in the Perrin zone on the east fork of Hulen Creek, and *P. shastalense* was described from the site of the old mining camp at Horsetown. The group of related forms to which *P. occidentale* belongs includes the next four species to be described, and ranges from the upper part of the Paskenta group to the top of the Horsetown group.

Phylloceras trinitense Anderson, n. sp.

(Plate 55, figures 3, 4, 5, 6)

This species belongs to the group represented by *P. occidentale* and may be contemporary with it. It is of medium size, the holotype being 52 mm. in diameter. The umbilicus is slightly larger and more open than in *P. occidentale* and is bordered by smooth slopes from the upper part of which primary ribs arise and cross the ventral zone without interruption or weakening; ribs often branching a little below the ventral zone; the secondary ribs arising near the middle of the side, and with growth extending downward toward the umbilical slope; all ribs arising as simple linear ridges, equally spaced, and inclining forward; interspaces two or three times the width of the ribs themselves; suture lines not shown on the holotype. Holotype (Calif. Acad. Sci. type Coll.) has the following dimensions, as measured on the cast: greatest diameter, 52 mm.; width of umbilicus, 5 mm.; height of whorl, 30 mm.; width of whorl, 24 mm. This shell differs from *P. occidentale* in having stronger and sharper, often branching ribs that continue without weakening across the ventral zone. The holotype was found in the detached area of Lower Cretaceous beds on Redding Creek, eastern Trinity County, where it was associated with species of *Goniomya*, *Glycymeris*, *Pleuromya papyracea*, and other pelecypods. Probably from this area the holotype of *Crioceras latum* Gabb, which is most abundant in the upper part of the Paskenta group, was originally derived. The same species, or one closely related to it, was found by E. L. Packard in the Lower Cretaceous beds at Riddle, Oregon, and was loaned to the California Academy of Sciences for study and comparison. Its association in the Riddle locality with species of *Neocomites* indicates a low position in the Cretaceous column, possibly near its base.

Phylloceras sextoni Anderson, n. sp.

(Plate 12, figure 3)

Shell small, moderately inflated, costate, with costae of two kinds; primary costae forming first at a diameter of 15 mm.; at this stage possessing about 8 to 1 cm., arising on the umbilical slope and extending upward at right angles to the periphery, crossing the ventral zone without interruption, not inclining forward in young stages; secondary costae arising above the middle of the sides, less numerous than the primary; umbilicus small, or nearly closed, with gently sloping sides, forming a shallow, funnel-form depression, smooth or polished within; sides of shell flattened; periphery flatly rounded, the section of the whorl being subquadrate in young stages. The holotype (Calif. Acad. Sci. type Coll.) was found near the Jordan gate on the Ono-Beegum road, 5 miles south of Ono, Shasta County. It possesses about 44 ribs, most of which are primary. It has the following measurements:

greatest diameter, 27 mm.; width of umbilicus, 2 mm.; height of whorl, 17 mm.; thickness of whorl, 14 mm.; umbilical ratio, .074:1.

As far as known, the stratigraphical position of this species is probably in the Mitchell zone of the Horsetown group. A second example of the species was found in the same zone on Roaring River west of the Millsap road. Another example that seems to be closely related, if not identical to this, was found by N. E. A. Hinds near the Clements ranch, eastern Trinity County, in beds that seem referable to the upper part of the Paskenta group (Valanginian).

This species is named in recognition of the interest and fine spirit of cooperation shown throughout the progress of this work by Miss Veronica Sexton, Librarian of the California Academy of Sciences.

Phylloceras theresae Anderson, n. sp.

(Plate 12, figures 4, 5)

Shell of medium size, inflated, smooth, or only faintly striated; umbilicus small, but not closed, deeply funnel-form; transverse section of whorl broadly elliptical, or nearly circular; striae when present rising almost vertically; suture line complex, having broadly ovate terminations on the finer divisions of the saddles; young shells showing no transverse striations. In outward form, disregarding costal lines, this species resembles *P. occidentale*, from which it can be distinguished by its more inflated section, broader whorls, smoother surface in young stages, and in older age, its more numerous costae, which cross the ventral zone without diminution. The holotype shows no costae until it attains a diameter of 50 mm. The suture line is not clearly shown on the holotype but, as seen on other examples from the same bed, it resembles that of *P. rouyanum* d'Orbigny, as illustrated by Kilian (1907–1910, pl. 6).

The holotype (Calif. Acad. Sci. type Coll.) has the following measurements: greatest diameter, 65 mm.; width of umbilicus, 6.5 mm.; height of whorl, 36 mm.; width of whorl, 32 mm.; umbilical ratio, .100:1.

The holotype was found at Locality 1668 (Calif. Acad. Sci.) on the west branch of Hulen Creek, Shasta County, associated with *Desmoceras merriami* (Anderson), *Douvilleiceras mammillatum* var., and *Diptychoceras laeve* Gabb. Five smaller, well-preserved examples were found in the same zone at Locality 152 (Calif. Acad. Sci.), associated with *Cleoniceras leconteï* and species of *Sonneratia*. Stoliczka has figured a form which he referred to *P. rouyanum* d'Orbigny, but which was later called *P. forbesianum* by Kossmat. The present species resembles this form, but cannot be identified with it.

An example of this species was obtained from the highest bed of the Horsetown group exposed on McCarthy Creek, Tehama County, in apparently the same zone.

Phylloceras shastalense Anderson

(Plate 12, figure 6)

Phylloceras shastalense Anderson, Calif. Acad. Sci., Pr., 3d ser., vol. 2, 1902, p. 80, pl. 4, figs. 112–115; Horsetown, Shasta County.

Shell small, globose, increasing rapidly in diameter, section of whorl broadly elliptical; umbilicus nearly closed in mature shells, slightly open in immature stages; surface marked by transverse ribs which are somewhat coarser than on any of the related species; ribs rarely extending to the umbilical pit, heaviest on the periphery. Most of the ribs begin near the umbilical border and extend outward with a slight forward curve. The diameter of the largest example seen is about 30 mm., with most of the body-chamber missing. The suture line is that of a true *Phylloceras of the group of P. theresae, P. occidentale, and P. trinitense, all found in earlier beds.*

The nearest European analogue, although much earlier, is *P. infundibulum* d'Orbigny. This species does not appear to be closely related to either *P. velledae* Michelin, *P. onoense* Stanton, or *P. aldersoni* nov., but it belongs in the lineage of *P. occidentale* nov. The holotype of this species is in the Museum of Paleontology, University of California, and was found by the writer at the old mining camp of Horsetown, Shasta County, in the uppermost beds of the Horsetown group. A topotype of the species is in the collections of the California Academy of Sciences.

Phylloceras onoense Stanton

(Plate 11, figures 1, 2)

Ammonites ramosum, GABB (not MEEK), Paleont. Calif., vol. 1, 1864, p. 63, pl. 11, figs. 12, 12a; pl. 12, fig. 12b; Lower Cretaceous, Cottonwood Creek, Shasta County.

Phylloceras onoense STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 74; Horsetown beds, Shasta County.

Phylloceras ramosum (Meek) is a species belonging strictly to the Upper Cretaceous (Senonian) of the West Coast, and has not been found in the Shasta series.

Gabb erroneously identified a species found in the Cottonwood district with that of Meek, as was pointed out by Stanton. Gabb's figures of the Horsetown species are defective, although there can be no doubt as to the form he endeavored to represent. To this species Stanton has given the name *Phylloceras onoense*.

The shell of this species is discoidal, compressed, or somewhat lenticular, with a small but open umbilicus; sides flattened, but sloping to a narrowly rounded periphery; surface at first almost smooth, but with growth it acquires numerous rounded, radiating threads (18 to a centimeter in adult specimens), separated by concave interspaces, broader than the threads; costal threads arising near the umbilicus, curving at first forward, then rising vertically, and finally curving gently forward on approaching the periphery. Gabb's (1864, pl. 11, fig. 12) figure shows the curvature of these lines to be backward, contrary to fact, and the suture lines do not show correctly the phylliform terminations that are characteristic of this species. The smaller terminations on the saddles are obovate, showing the species to be a true *Phylloceras*. Its horizon is commonly in the middle Horsetown group (Bedoulian), in which beds it is usually associated with *Lytoceras argonautarum*, *Parahoplitoides cerrosensis* nov., and *Acrotuthis aboriginalis* nov. Six or more good specimens were collected from the Argonaut zone at Locality 1347 (Calif. Acad. Sci.), half a mile east of Mitchell Creek and 5 miles south of Ono, Shasta County.

The example figured by Gabb has been listed as being in the Museum of Paleontology, University of California, by Merriam (1895, p. 1), but it has not been found. Under the circumstances attached to this specimen, it seems better to propose a lectotype for the species, and a more complete example (Calif. Acad. Sci. type Coll.) is selected to represent it. This example was obtained on the west branch of Bee Creek, half a mile east of the Shoup ranch house, in the Argonaut zone. It has the following dimensions: greatest diameter, 120 mm.; width of umbilicus, 7 mm.; height of whorl, 65 mm.; thickness of whorl, 35 mm.; umbilical ratio, .058:1. Some fragmentary examples of the species have been found which indicate an original diameter of 12 inches, although the usual size is about 4 to 6 inches. It differs from *P. knoxvillense* Stanton in its finer ribbing, and distinctly different suture lines, particularly in its broad, short siphonal saddle. It also differs from *P. californicum* nov., in its finer and more sinuous costal lines, in its thinner section, and in its lower horizon.

Phylloceras aldersoni Anderson, n. sp.

(Plate 11, figures 3, 4, 5, 6)

Shell small, discoidal, slightly inflated, rounded on the sides which slope rapidly to the periphery; umbilicus small, with steep walls curving roundly to the sides; surface mostly smooth, or polished, but marked by six or more slightly sinuous periodic constrictions, between which are numerous fine costal lines (10 or more to a centimeter) arising on the umbilical walls, curving at first forward, then gently backward, and again forward on approaching the ventral border; intercostal spaces relatively wide and smooth; cross-section of whorl somewhat elliptical, being broadest near the middle of the side, and rounding off above and below.

The suture line is not unlike that of *P. onoense* Stanton, although the septa are more numerous and more crowded, and also more complicated; the small siphonal saddle is narrower and more pointed. The essential differences between this species and the latter are in its smaller size, more inflated sides, its periodic constrictions, and the form and character of its costal markings. The largest specimen of this species so far found has a diameter of 65 mm., including the body-chamber. About 14 examples of the species were obtained, most of them from Locality 1348 (Calif. Acad. Sci.) on Alderson Creek, 2 miles south of Ono, Shasta County. The holotype (Calif. Acad. Sci. type Coll.), septate throughout, has the following dimensions: greatest diameter, 40 mm.; width of umbilicus, 5 mm.; height of whorl, 21 mm.; thickness of whorl, 17 mm.; umbilical ratio, 0.125:1. All the examples came from the Alderson zone and were associated with *Melchiorites shastensis* nov., *Lytoceras batesi* (Trask), *Hamiticeras aequicostatum* nov., and a species of *Aucella* resembling *A. keyserlingi* Lahusen.

Phylloceras californicum Anderson, n. sp.

(Plate 12, figure 7)

This species is intermediate between *Phylloceras onoense* Stanton and the California form of *P. velledae* Michelin in both form of shell and in its stratigraphic position. It differs from both also in the character of its suture lines. The species occurs in the upper part of the Hulen beds (middle Albian) on Hulen Creek, and has also been found at the upper limit of the Horsetown group at the old mining camp of Horsetown on Clear Creek, Shasta County, where it is associated with *Puzosia hoffmanni* (Gabb) and *Beudanticeras brewseri* (Gabb).

The species differs from *P. onoense* in its thicker and more robust form, in its stronger and straighter costae, which have little forward curvature upon their approach to the ventral zone, and in sutural details. In its outward form it resembles the figures of *P. velledae* given by Stoliczka (1868, Pl. 19, figs. 1–4), although it is larger, whereas in the general and detailed character of its sutures it more nearly approaches *P. onoense* Stanton. *Phylloceras velledae*, or a closely related form, has been found in the lower beds of the Chico series half a mile east of the mouth of Hulen Creek, and about 1100 feet above the position of *P. californicum* of the Horsetown group.

The holotype (Calif. Acad. Sci. type Coll.) is a large fragment, representing an individual 8 inches (203 mm.) in diameter, obtained from the upper part of the Hulen beds, 50 feet beneath the Neptune zone at Locality 1569 (Calif. Acad. Sci.).

Phylloceras umpquanum Anderson, n. sp.

(Plate 30, figures 9, 10)

Shell small, robust, with small but deep umbilicus and inflated cross-section; surface thickly costate, with almost uniform, rounded costae, separated by some-

what broader interspaces; costae arising near the umbilical border, inclined strongly forward at first, then rising nearly normal to the periphery; suture lines not clearly shown. The species belongs to the group represented by *P. trinitense*, nov. but it is somewhat less inflated and has finer and more numerous costae. The holotype, which is the property of Oregon State College, measures as follows: greatest diameter, 33 mm.; greatest thickness, almost 20 mm. The umbilicus is small, but not closed; the ratio of height to width of whorl is near 5:4. It was found by E. L. Packard, at Locality 268 (Oregon St. Coll.), a mile east of Riddle, Oregon. Its horizon is the same as that of *Neocomites riddlensis*, nov., with which it occurs.

Phylloceras oregonense Anderson, n. sp.

(Plate 30, figures 8, 9)

Shell similar in form and sculpture to the preceding but it is relatively thinner and has a smaller umbilicus. The holotype, which is in the collections of the Oregon State College, has the following dimensions: greatest diameter, 40 mm.; maximum thickness, 16 mm.; width of umbilicus, 5 mm. It was found by E. L. Packard and was found with *P. umpquanum* at Locality 268 (Oregon State Coll.) a mile east of Riddle, Douglas County, Oregon.

Phylloceras myrtlense Anderson, n. sp.

(Plate 30, figure 7)

This species is characterized by a more compressed form than any of the preceding species. The holotype has the following dimensions: greatest diameter, 35 mm.; width of umbilicus, 5 mm.; maximum thickness, 10 mm.; suture line not shown; sides numerously costate with costae of two ranks; major costae arising at the umbilical border; secondary costae arising near the middle of the side; all crossing the periphery, and all tending to branch above the middle of the side. The holotype, belonging to the Oregon State College, was found at Locality 268 (Oreg. State Coll.), a mile east of Riddle, Oregon, where it was found associated with *P. umpquanum*, *Neocomites riddlensis*, *Lytiococeras packardi*, *Dichotomites oregonensis*, and *Hoplocrioceras* cf. *remondi* (Gabb). The horizon is thought to be upper Valanginian and to represent the upper part of the Paskenta group, as known in California.

LYTOCERATIDAE Neumayr

Lytoceras Suess

The genus *Lytoceras*, in its broader sense, is distributed stratigraphically almost throughout the Shasta series in California, appearing first in a single species in its lowest beds, and in increasing numbers and variety as the column is ascended; near the close of the Horsetown group it attains its greatest development, but it continues into the lower beds of the Chico series, and appears again in its later (Senonian) beds.

The genus existed in the Great Valley trough during the closing epoch of the Knoxville period; the Tithonian stock did not continue into the Shasta series. The earliest form of *Lytoceras* known in the Shasta series seems to have entered the trough at the beginning of its sedimentation in early Valanginian time. This was *Lytoceras saturnale*, nov. It was followed in middle Valanginian time by *Lytoceras aulaeum* nov., and toward the end of this epoch by *Lytoceras traski* nov.; none of these were very nearly related.

This last form continued into the lower Horsetown group (Ono zone), where it seems to have disappeared. At the opening of Aptian time a new assemblage of lytoceratids appeared, consisting of types which, except for one species, do not seem

to have near relationships with those of earlier date. *Lytoceras batesi* (Trask) appears for the first time in Bedoulian time, but continues for only a short span and is replaced by others in Gargasian and later time. Still later, in Albian time, another assemblage entered the embayment, but there seems to have been little, if any, relations between its constituents and those of the earlier "waves." Thus in the course of the Shasta period three or more groups of lytoceratids, having no close relationships, appeared in succession. It would be in harmony with the physical history of the West Coast during this period if these successive "waves" were regarded as being so many distinct immigrations, or invasions, coming from distant regions in which they had been cradled. Some of these stocks seem to have allies in southwest Asia (Spiti, Cutch, etc.). The lytoceratids of the Shasta series can be separated into as many as six subgeneric groups, followed by others in the early part of the Chico series (Cenomanian).

The order of their occurrence appears to be about as follows:

(1) Valanginian time.—
Lytoceras (*Saturnoceras*) *saturnale*, n. subgen., n. sp.
L. traski n. sp.
L. rel. *traski* n. sp.
L. aulacum n. sp., rel. *L. saturnale*, nov.

(2) Aptian time.—
Gabbioceras angulatum Anderson; *G. wintunium* n. sp.
Lytoceras (*Argonauticeras*) *argonautarum* (Anderson)
L. batesi (Trask)

(3) Albian time.—
Lytoceras (*Gaudryceras*) *sacya* (Forbes)
L. (? *Gaudryceras*) *neptunianum* n. sp.
L. (*Kossmatella*) *whitneyi* (Gabb)
L. (*Kossmatella*) *aurarium* n. sp.
L. (? *Kossmatella*) *gainesi* n. sp.

(4) Cenomanian time.—
Forms of *Gaudryceras* and *Tetragonites*, only, are known from the Chico series, following the close of the Shasta series.

Lytoceras (*Saturnoceras*) *saturnale* Anderson, n. sp.; n. subgenus

(Plate 13, figure 1)

In his account of *Lytoceras batesi* (Trask), Gabb (1864, p. 67) refers to an incomplete specimen 15 inches in diameter, found in the Bald Hills, Shasta County; he gives also other measurements. This specimen is in the Museum of Paleontology, University of California, and has been examined with much care. Very clearly it does not belong to the species to which Gabb referred it, nor is it nearly related to it. This example constitutes the holotype of the present species, and the genotype of the group to which it belongs. It has the following dimensions: greatest diameter, 16.5 inches (419 mm.); width of umbilicus, 7 inches (178 mm.); height of whorl, 5.5 inches (138 mm.); width of whorl, 6 inches (152.5 mm.); umbilical ratio, 0.424:1.

It was at one time thought that this specimen might represent *Lytoceras argonautarum* Anderson, but later collections and comparison with examples of the latter proves that this was an error; the two forms are not nearly related.

Stanton (1895, pl. 13) has figured a lytoceratid from the Wilcox ranch, Tehama County that seems to conform to the characters of the holotype, insofar as can be determined. Stanton notes the crenulations on the costal ridges and compares it to *Amm. crenocostatus* Whiteaves, later referred by its author to *L. batesi* (Trask). Stanton's example came from the Paskenta group on the Wilcox ranch, from which

others have since been collected. The species occurs at other horizons in this group, extending from its base to near its top. Unfortunately, the exact locality of the holotype is not yet known, although it is believed to have been found in the upper part of the Paskenta group in the Cottonwood district, Shasta County, from which fragments have been collected. In actual diameter, though not in weight, this is the largest example of *Lytoceras* yet seen from the Lower Cretaceous of California, although fragmentary specimens indicate larger individuals. If the body-chamber to the extent of half a whorl were restored to the holotype, its total diameter would be at least 26 inches.

The costae of this specimen show crenulations similar to those noted by Stanton on the form figured by him. Another example in the Museum of Paleontology, University of California, about 7 inches in diameter, shows the same characters. This species differs from most of the following in its more robust form, in its more restrained sculpture, and in the cross-section of its whorls. The form figured by Whiteaves (1884, pl. 27, fig. 1) under the name of "*Lytoceras batesi* Trask" may represent this species. As it was obtained at Bearskin Bay, north shore of Skidegate Inlet, it may have come from the *Aucella*-bearing beds of that locality. In form and ornamentation this species is not unlike *Lytoceras liebigi* (Oppel) from the Tithonian beds of Moravia.

Lytoceras saturnale has a stratigraphic range almost throughout the Paskenta group in its type district, and has been found in the Cottonwood district at various levels in the same group. It has not been found in Knoxville beds at any place.

Lytoceras traski Anderson, n. sp.

(Plate 15, figures 1, 2; plate 17, figure 2)

Mature shell of moderate size, discoidal, somewhat robust, intermediate in form between *L. saturnale* and *L. batesi*; section of whorl subcircular, a little higher than broad, narrowing slightly toward the periphery; surface marked by both major and more numerous minor costal lines; major costae appearing only at intervals of 10 to 12 minor costae, arising as thin, prominent threads with broken edges.

This species appears to belong to the group which includes *Lytoceras anisoptychum* Uhlig, from the Wernsdorfer beds, although it seems to have fewer and more prominent major costae, not showing the "crinkley" character of the latter form. It also resembles *Lytoceras exoticum* (Oppel) somewhat, although this resemblance may be only in its ornamentation. A few shallow constrictions appear at irregular intervals on the septate portion of the whorl. The holotype (Calif. Acad. Sci. type Coll.) has the following dimensions: greatest diameter, 125 mm.; width of umbilicus, 50 mm.; height of whorl, 45 mm.; width of whorl, 43 mm.; umbilical ratio, 0.4:1.

The sutural lines are similar to those of *L. batesi* (Trask), as illustrated by Gabb. The holotype was found at Locality 1347 (Calif. Acad. Sci.) north of Roaring River, not far east of Mitchell Creek, in the Cottonwood district, associated with *Lytoceras argonautarum*, *Gabbioceras angulatum*, *Phylloceras onoense*, and *Parahoplitoides cerrosensis*, in the Argonaut zone. Its usual occurrence is in the lower part of the Horsetown group. In the Cottonwood district it occurs lower, but is not abundant in lower strata, occurring sparingly in the upper part of the Paskenta group. The species is represented by eight or more specimens in the collections of the California Academy of Sciences.

Lytoceras aulaeum Anderson, n. sp.

(Plate 14, figures 1, 2, 3, 4)

This species somewhat resembles *Lytoceras saturnale* in form, although it is less robust, and the resemblance is chiefly in the surface markings. In section of whorl

it differs from it notably, having a section higher than broad, which is the reverse of the other; there are greater differences in sculpture. In its younger stages the shell of *L. aulacum* is often smooth, but this condition is soon lost. When the costae begin to appear they are less regularly spaced but with growth they become more uniform. The interspaces are at first relatively broad but later become occupied by secondary costal lines. In mature shells the costae become more crowded, costal lines appearing even on the slopes of the primary costal ridges. In young stages the costal lines in the ventral zone are crossed by fine revolving lines parallel to the siphonal plane. In older specimens these revolving lines spread downward on the sides of the shell. In more mature stages these intersections of the costal lines break up, and the costal ridges become crenulated, producing on the surface of the shell a reticulated lace-like pattern, as shown in the figure. The crenulations form points on the posterior side of the costal ridge, leaving the anterior side looped or nearly smooth. In its sculptural features the shell resembles *Amm. subfimbriatus* d'Orbigny, from the Neocomian of France, although the costae are much less crowded, and there are other obvious differences. The holotype (Calif. Acad. Sci. type Coll.) is a nearly complete specimen, having a portion of the shell preserved. It was obtained at Locality 113 (Calif. Acad. Sci.) in the Hamlin-Broad zone at the head of the west branch of Mitchell Creek, 4 miles southwest of Ono, Shasta County. It was found associated with species of *Polyptychites* and of *Simbirskites*. Specimens of the same species were found on Fiddler Creek, a mile above its mouth beneath a thick bed of conglomerate which seems to mark the base of the Horsetown group.

Fragments of the same species have been found in the lower beds of the Horsetown but for the most part it seems to characterize the upper part of the Paskenta group in the Cottonwood district; it has not yet been found in the district south of Elder Creek. Measurements on the holotype gave the following dimensions: greatest diameter, 237.6 mm.; width of umbilicus, 118.7 mm.; height of whorl, 68.5 mm.; width of whorl, 61.5 mm.; umbilical ratio, 0.5:1.

The horizon of the holotype is in the upper beds of the Paskenta group, about 500 feet beneath the conglomerates that mark the base of the Horsetown group in the Cottonwood district. This horizon is perhaps near the upper limit of *Lytoceras saturnale*, and as judged from its associates it represents an upper part of the Valanginian column in European chronology.

Lytoceras batesi (Trask)

(Plate 16, figure 1; plate 17, figure 1)

Ammonites Batesi TRASK, Calif. Acad. Sci., Pr., vol. 1, 1855, p. 39; "Arbuckle Diggings," Shasta County—GABB, Paleont. Calif., vol. 1, 1864, p. 67, pl. 13, figs. 16, 16a, 16b; locality as above.

Lytoceras batesi, STANTON (in part), U. S. Geol. Surv., Bull. 133, 1895, p. 75, (not pl. 13, fig. 11; Wilcox ranch, Tehama County—ANDERSON, Calif. Acad. Sci., Pr., 3d ser., vol. 2, 1902, p. 84.

This species is discoidal, moderately robust, with almost circular cross-section, and distinctive ribbing, unlike that of any of its congeners. The surface ornamentation is clearly given by Trask, as follows (in part):

"Well defined costae on each whorl, which appear uninterrupted, and on the last convolution (whorl) are about one-tenth of an inch asunder; the ribs become more approximate toward the ventral (dorsal) portion of the whorl; between the larger ribs are seen smaller divergent rudimentary costae. . . ."

Although Gabb claimed to have figured "one of Trask's original specimens," his diagnosis must be accepted with caution, since he confused at least three other quite distinct forms with this species. Others have followed his example.

In good specimens of this species secondary costae first appear on the young shells near the ventral zone, and with growth these extend downward to the dorsum. In such specimens, up to a diameter of 100 mm., the costae are simple linear ridges, often acute, separated by broadly concave interspaces; with growth the costae become broader and more rounded, and the interspaces are relatively narrower. At a diameter of 100 mm. the interspaces begin to become occupied by secondary costae, which in more mature stages assume the rank of primary costae. These costal ridges remain simple throughout, although some writers have believed that well-preserved specimens show crenulated ribs.

Inspection of a large number of representative examples in good preservation has failed to confirm this view. In most if not in all cases in which crenulations appear, critical measurements show departure from the type form.

The holotype of the species was the property of the California Academy of Sciences, and was lost in the San Francisco fire of 1906. Many good specimens have since been found, and are in the collections of the Academy. Many of them have been carefully measured, and are found to depart but little from type. A representative example, 110 mm. in diameter, gives the following results: width of umbilicus, 53.5 mm.; height of whorl, 33 mm.; width of whorl, 33 mm.; umbilical ratio, 0.486:1.

From the loss of the holotype it has become permissible to choose a lectotype for the species. This lectotype (Calif. Acad. Sci. type Coll.) has the following dimensions: greatest diameter, 165 mm.; width of umbilicus, 85.5 mm.; height of whorl, 51 mm.; width of whorl, 51.5 mm.; umbilical ratio, 0.500:1.

The largest example of this species thus far seen was found on the North fork of Cottonwood Creek, near Ono. It had a diameter of about 14 inches, but showed no fluting on the ribs. Six or more good specimens of this species from the same district are in the Museum of Paleontology, University of California, and many more are in the collections of the California Academy of Sciences, and in other collections.

The stratigraphic range of the species is not definitely known, but insofar as it is known the species is confined to the lower half of the Horsetown group and is most abundant in the upper part of this half. The lectotype, with various other examples of the species, was obtained at Locality 1347 (Calif. Acad. Sci.) in the Bald Hills, east of Mitchell Creek, about 5 miles south of Ono, Shasta County.

A representative example, the property of the Academy of Natural Sciences of Philadelphia, is figured on Plate 16 of this paper. It has the following dimensions: greatest diameter, 135 mm.; width of umbilicus, 65 mm.; height of whorl, 40 mm.; width of whorl, 40 mm.; umbilical ratio, 0.481:1. The locality from which this example was obtained, unfortunately, is not known, but it seems to have come from the Cottonwood district in Shasta County.

Lytoceras (*Argonauticeras*), new subgenus

Genotype, *Lytoceras argonautarum* Anderson

Among the many subgeneric groups of *Lytoceras* (*s. l.*) found in the standard paleontological literature none seem adapted to include this type from the middle Horsetown group of the Shasta series, and similar forms described from other regions. Probably this group should include *Lytoceras belliseptatum* Anthula (1899, p. 97, pls. 6 (5), 7 (6)) and perhaps also *Lytoceras ezoense* Yabe (1903, p. 9, pl. 1, fig. 1) from the Lower Ammonite beds of Hokkaido, Japan. In this group of lytoceratids the increment of growth and an unusual cross-section of whorl are its distinguishing features. The genotype of the group is also the holotype of the leading species. This is an incomplete, wholly septate whorl having the following dimensions: great-

est diameter, 171 mm.; width of umbilicus, 57 mm.; height of whorl, 70 mm.; width of whorl, 84 mm.; umbilical ratio, 0.333:1. It consists of the inner whorls of a shell whose diameter had been more than 24 inches (60.96 centimeters). The removal of one whorl from this example would reduce its diameter to one-fifth of its present measure. If the increment of growth were by heights of whorl in adjacent coils these ratios for the holotype would be: 1:3; for a second example from Locality 1347 (Calif. Acad. Sci.), 1:3.3; and for the small figured specimen, 1:2.6. These several ratios seem to reflect the size (and ages) of the examples measured. Other characteristics of the group will appear in the description of the holo-genotype.

Lytoceras (*Argonauticeras*) *argonautarum* (Anderson)

(Plate 17, figure 3; plate 19, figures 1, 2)

Lytoceras argonautarum Anderson, Calif. Acad. Sci., Pr., 3d ser., vol. 2, 1902, p. 85, pl. 7, figs. 154, 155; middle Horsetown group, Cottonwood district, Shasta County.

Shell large, coiling lytoceratid, much inflated, increasing rapidly in diameter; section of whorl subcircular, broader than high, flattened on the sides and on the ventral zone; involution slight, having on the dorsum only an impressed zone; surface of shell ornamented by evenly spaced costae with acute "crinkley" edges, hardly crenulated; suture line partly shown in the figure; first lateral lobe not quite symmetrically bipartite; small siphonal saddle lanceolate in general outline.

An example of this species, found at Locality 1347 (Calif. Acad. Sci.) near Mitchell Creek, has the following dimensions: greatest diameter, 250 mm.; width of umbilicus, 87 mm.; height of whorl, 113 mm.; width of whorl, 125 mm.; umbilical ratio, 0.348:1.

This species characterizes the Argonaut zone (middle Aptian) of the Horsetown group, where it is associated with *Gabbioceras angulatum*, *Phylloceras onoense* Stanton, and *Parahoplitoides shoupi* nov. The species (and zone) has been found on Hulen Creek, Roaring River, and Middle fork of Cottonwood Creek. Good examples of the species were collected by R. M. Kleinpell and E. Wayne Galliher north of Skidegate Indian village, near Village Bay, Graham Island, associated with *Desmoceras voyi* Anderson, *Aucella indigenalis* nov., and *A. terebratuloides* Lahusen. Gabb (1869a, p. 132) seems to have included this species in his description of *Lytoceras batesi* (Trask), regarding it as a variety "in which the whorls increase much more rapidly in size." The species has been found in beds much below the Argonaut zone in this district.

Gabbioceras Hyatt, 1896

Genotype, *Ammonites Batesi* Gabb (in part), Paleont. Calif., vol. 2, 1869, p. 132, pl. 20, figs. 9, 9a; pl. 21, figs. 10, 10a, 10b; (not *Amm. batesi* Trask; not *Amm. batesi* (Trask) Gabb, Paleont. Calif., vol. 1, 1864, pl. 13, figs. 16a, 16b).

Gabb gave a good description and figures of a lytoceratid species in the second volume of his work on California fossils, but erroneously referred it to *Amm. batesi* Trask. This species was later made the genotype of *Gabbioceras* by Hyatt, and in 1902 it was described as *Lytoceras* (*Gabbioceras*) *angulatum*, nov. by Anderson. The holotype of the species is in the Museum of the Academy of Natural Sciences of Philadelphia.

Charles Jacob (1907, p. 17) proposed the generic name "*Jaubertella*," taking as the genotype *Amm. Jaubertianus* d'Orbigny, said to have come from the Aptian marls of Barremme. Hyatt's name first appeared in Eastman's translation of Zittel's Textbook of Paleontology (1900, p. 570). If the two species taken as genotypes by Hyatt and Charles Jacob respectively prove to be closely related forms, as they appear to

be, the rule of priority would make the name "*Jaubertella*" a synonym of *Gabbioceras* Hyatt, and it should be discarded.

Lytoceras (Gabbioceras) angulatum Anderson

(Plate 15, figures 3, 4; plate 35, figure 2)

Ammonites Batesi, Gabb (in part), Paleont. Calif., vol. 2, 1869, p. 132, pl. 20, figs. 9, 9a; pl. 21, figs. 10, 10a, 10b; (not *Amm. Batesi* Trask, Calif. Acad. Sci., Pr. vol. 1, 1855, p. 40)—Gabb, Paleont. Calif., vol. 1, 1864, p. 67, pl. 13, figs. 16, 16a, 16b.

Lytoceras (Gabbioceras) angulatum Anderson, Calif. Acad. Sci., Pr., 3d ser., vol. 2, 1902, p. 87, pl. 6, fig. 139; plesiotype at the University of California.

This species was well described by Gabb, who erroneously regarded it as a variety of *Lytoceras batesi* (Trask). Concerning this form he says (in part):

"A third variety has since been obtained, in which, in the young state, up to an inch, or an inch and a half in diameter, the whorls are broader than high, the dorsum (venter) broadly rounded, and the umbilicus occupies more than half the diameter of the shell, is funnel-shaped, very deep, and is bordered by a sharp angle, the surface between this angle and the suture being flat. As the shell of this variety grows older, the angle disappears, the flattening gradually rounds out, and the older shell assumes the normal form of the species, except that it bears an occasional well-marked, rounded, slightly sinuous rib."

The holotype of this species is in the Museum of the Academy of Natural Sciences of Philadelphia. The locality of its discovery is not definitely known, although its horizon is probably near that of the Argonaut zone, in which it has been found at Locality 1347 (Calif. Acad. Sci.), and on Alderson Creek, 2 miles south of Ono, Shasta County. Its range is stratigraphically not very great.

Lytoceras (Gabbioceras) wintunium Anderson, n. sp.

(Plate 15, figure 5; plate 16, figures 2, 3, 4, 5)

Lytoceras rel. *duvalianum* Anderson (in part), Calif. Acad. Sci., Pr., 3d ser., vol. 2, 1902, p. 81, (not pl. 6, figs. 140, 143).

By some oversight some confusion resulted in the earlier discussion of this species, since there was figured for it a much later type. The error was discovered too late for correction, and this opportunity is taken for its re-description. In its younger stages, as well as at maturity, the whorls of this species are quadrate in section, and thus are "gradumbilicate"; in this respect it differs from the preceding species. In young stages the sides and ventral surface are flattened, but in adult stages this feature is lost and the whorls become rounded. At a diameter of 30 millimeters the shell has acquired 10 to 12 forward-curving periodic constrictions which cross the ventral zone without a sinus. Between these constrictions the surface is marked by numerous fine lines of growth which sometimes become prominent. The holotype (Calif. Acad. Sci. type Coll.) has the following dimensions: greatest diameter, 57 mm.; width of umbilicus, 20 mm.; height of whorl, 23 mm.; width of whorl, 24 mm.; umbilical ratio, 0.337:1.

This species has been found sparingly in the Argonaut zone, middle Horsetown group, at Locality 1347 (Calif. Acad. Sci.), and in the same horizon on Alderson Creek. Its nearest European analogue is probably "*Jaubertella*" *jaubertiana* (d'Orbigny). The holotype was obtained at Locality 1348 (Calif. Acad. Sci.) on Alderson Creek, 2 miles south of Ono, Shasta County.

Gaudryceras Grossouvre

Genotype, *Amm. duvalianum* d'Orbigny

The basis of Grossouvre's characterization of this subgenus is primarily in the form and ornamentation of the shell. At first sight the shell resembles that of *Lytoceras* (*s.s.*), both in form and ornamentation, but these features are soon lost. According to Grossouvre:

"In most of the forms of this group, the whorls clasp very lightly in youth and ordinarily are little involute" and "the shell presents the appearance of a true *Lytoceras*, then the dimensions of the whorls increase rapidly in size and especially in height, the involution becomes accentuated, and the aspect of the shell changes notably."

In the upper part of the Horsetown group, species within the range of this definition are not uncommon, most of them coming in the middle or upper Albian, associated with *Beudanticeras brewer*i (Gabb) and *Douvilleiceras mammillatum*, var. At least three distinct species are found in the Hulen beds, north of Cottonwood Creek. None have been found outside of the Cottonwood district in California.

Lytoceras (*Gaudryceras*) *sacya* (Forbes)

Ammonites sacya Forbes, Geol. Soc. London, Tr., 2d ser., vol. 7, 1845-1856, p. 113, pl. 14, figs. 10, a, b; southern India—Stoliczka, Paleont. Ind., vol. 1, 1865, p. 154, pl. 75, figs. 6, a, b; figs. 7, a, b; Ootatoor group—Whiteaves, Mes. Foss., vol. 1, pt. 2, 1884, p. 203, pl. 25; Bearskin Bay, Skidegate Inlet, Queen Charlotte Islands—Stanton, *in* Dillee and Stanton, Geol. Soc. Am., Bull., vol. 5, 1894, p. 445—Whiteaves, Mes. Foss., vol. 1, pt. 4, 1900, p. 270—Anderson, Calif. Acad. Sci., Pr., 3d ser., vol. 2, 1902, p. 82; upper part of Horsetown beds, Hulen Creek, Cottonwood district, Shasta County.

This species has been found in the upper beds of the Horsetown group on Hulen and Cottonwood creeks, but it is less abundant than has been supposed. In the form found in California the section of the whorl is not quite circular, being higher than broad. An average example has the following relative dimensions: greatest diameter, 85 mm.; width of umbilicus, 33 mm.; height of whorl, 38 mm.; width of whorl, 34 mm.; umbilical ratio, 0.388:1.

Four good examples of this species were collected by R. M. Kleinpell and E. Wayne Galliher in 1929, near the Indian village of Skidegate, Graham Island. They were given to the California Academy of Sciences, with other species with which they were associated, and have been compared with the California types. In young stages, up to a diameter of 65 mm., the shell is almost smooth; at this diameter the surface begins to show undulations on the sides, and a little later on the periphery of the shell; these soon develop into characteristic ribs inclined obliquely forward, in the manner shown by Whiteaves.

Lytoceras (*Kossmatella* ?) *aurarium* Anderson, n. sp.

(Plate 20, figures 1, 2)

The shell of this species is of medium size, discoidal, somewhat compressed, moderately involute, nearly smooth in young stages, becoming costate in older stages, as shown chiefly in the irregularly spaced growth lines; sides crossed by five or six straight, transverse periodic constrictions; umbilicus broad, walls nearly vertical below, rounded above to the slightly compressed sides; section of whorl broadly elliptical, higher than broad; ventral region narrower than the dorsal half of the shell; section changing with growth from a nearly circular form in youth to the elliptical form in older stages; surface of shell nearly smooth, except for the periodic

constrictions and growth lines; suture line lytoceratid, but not well shown on the holotype; species plentiful in the Neptune zone at Locality 1659 (Calif. Acad. Sci.) on the east branch of Hulen Creek, Shasta County.

The holotype (Calif. Acad. Sci. type Coll.), an adult shell, has the following dimensions: greatest diameter, 83 mm.; width of umbilicus, 24 mm.; height of whorl, 40 mm.; width of whorl, 30 mm.; umbilical ratio, 0.298:1.

In its older stages the shell develops transverse undulations, not unlike those of *Gaudryceras sacya* (Forbes), which may indicate either relationship, or developmental tendencies. These undulations do not appear until the shell reaches a diameter of 90 mm. At this stage the section of the whorl becomes slightly flattened on the sides and ventral surface, approaching an elliptical form.

Ten good examples in all were obtained at Locality 1659, associated with *Beudanticeras brewer*i (Gabb), *Desmoceras merriami* (Anderson), and *Douvilleiceras mammillatum*, var.

Lytoceras (Gaudryceras ?) neptunium Anderson, n. sp.

(Plate 18, figure 1)

Shell very large, thick, and heavy; whorls few, increasing rapidly in cross-section and size; umbilicus wide, involution moderate; whorls rounded, broader than high; surface ornamented only by simple, rounded costae, about 10 to 11 to an inch on the body whorl (2.3 mm. apart), separated by narrow interspaces; size and weight of fossil excessive compared to other California species. The holotype of the species (Calif. Acad. Sci. type Coll.) has the following dimensions: greatest diameter, 16.5 inches (420 mm.); width of umbilicus, 7.3 inches (185 mm.); height of whorl, 7 inches (178 mm.); width of whorl, 7.6 inches (193 mm.); umbilical ratio, 0.440:1.

The specimen is incomplete, the body whorl being detached from the coil, which is intact. The suture line is entirely unknown. With the body-chamber attached the diameter of the whole measures 22 inches. This specimen was obtained at Locality 1659 (Calif. Acad. Sci.) on the east branch of Hulen Creek, where it was associated with many forms already mentioned. It is the largest cephalopod species, in point of weight, yet found in the Cretaceous of California, exceeding the dimensions of *Lytoceras saturnale*, whose holotype Gabb claimed to have been the largest. The stratigraphic horizon is that of the Neptune zone, assigned to an upper middle Albian position in the chronological scale.

Lytoceras (Kossmatella) whitneyi (Gabb)

(Plate 21, figures 1, 2)

Ammonites Whitneyi Gabb, Paleont. Calif., vol. 2, 1869, p. 134, pl. 22, figs. 14, 14a, 14b; "Shasta Group," Cottonwood Creek, Shasta County.

Few examples of this species have been found in the California Cretaceous, and it has not been recorded from any other West Coast area. The holotype is in the Museum of the Academy of Natural Sciences of Philadelphia, and by the courtesy of Dr. H. A. Pilsbry, loaned for study and comparison. A fairly well preserved specimen of the species has been found in the upper Horsetown beds on Dry Creek, northern Tehama County, associated with species of upper Albian age. In its early stages of growth the whorls have slightly greater involution than any other lytoceratid described herein. Below a diameter of 23 mm. the whorls are nearly circular in section, with abrupt umbilical walls and nearly smooth surface. At a diameter of 40 mm. the form begins to change, the height becoming greater than the width, and undulations begin to appear on the sides and ventral surface; at a diameter of 100 mm. the ratio of height to width of whorl is about 10:9, and with further growth

this ratio increases; the sides slope from below the median line to the periphery, the section of the whorl becoming subovate; the costal ridges form at about 40 mm. diameter, and are at first rounded, separated by interspaces of about the same width; at a diameter of 100 mm. these ridges become relatively narrow and cross the ventral zone; the suture line is known only from Gabb's figure (1869, pl. 22, fig. 14b). The holotype has the following dimensions: greatest diameter, 108 mm.; width of umbilicus, 40.6 mm.; height of whorl, 45 mm.; width of whorl, 39 mm.; umbilical ratio, 0.376:1.

Lytoceras (Kossmatella) gainesi Anderson, n. sp.

(Plate 20, figures 3, 4, 5)

Lytoceras rel. *duvalianum* (d'Orbigny) Anderson (in part), Calif. Acad. Sci., Pr., 3d ser., vol. 2, 1902, p. 81, pl. 6, figs. 140–143; upper part of Horsetown group, Hulen Creek and Horsetown, Shasta County.

Shell small, discoidal, moderately inflated, "gradumbilicate," section of whorl quadrate, higher than broad; surface marked by regularly spaced periodic constrictions, about 18 to the whorl, inclined forward; between these the surface is marked by numerous fine growth lines; both constrictions and growth lines becoming weaker, or quite disappearing upon the abdominal surface; sides and ventral zone somewhat flattened in older stages. In this species the umbilical ratio is smaller than in *Lytoceras duvalianum* (d'Orbigny), which belongs to a distinct subgenus.

The holotype of this species (Calif. Acad. Sci. type Coll.) has the following dimensions: greatest diameter, 58 mm.; width of umbilicus, 16.5 mm.; height of whorl, 24 mm.; width of whorl, 22 mm.; umbilical ratio, 0.284:1.

Twelve or more good examples were obtained at Locality 1650 (Calif. Acad. Sci.), in the Neptune zone, associated with *Puzosia hoffmanni* (Gabb) and other middle Albian forms. It has also been collected at the old mining camp of Horsetown, Shasta County, and at Texas Springs, 3 miles to the east.

Stephanoceratidae Neumayr

In the broader family Stephanoceratidae Neumayr, of the Mesozoic, later authors have recognized various subfamilies, among which Morphoceratinae Hyatt has found acceptance among many. In such relationship Pavlow and Lamplugh (1891, p. 470) grouped *Oicostephanus* Neumayr, *Polyptychites*, *Simbirskites*, *Astieria* and *Virgatites*.

Since then Spath (1924, p. 87) has proposed as family groups Simbirskitidae and Polyptychitidae, the latter of which seems to cover satisfactorily many western forms, including *Polyptychites*, *Simbirskites* Pavlow, and *Subastieria* and *Neocraspedites* of Spath. Some of the Pacific Coast forms, earlier included in "*Simbirskites*," appear to belong to the group of "*Craspedites fragilis*" Pavlow, rather than to *Simbirskites* of the group *S. decheni* Pavlow, which has been taken as a genotype. "*Craspedites fragilis*" Pavlow, thought by Spath to be distinct from *C. fragilis* Trautschold, is doubtfully placed by him in his subgenus *Dichotomites*, and in this lineage belong several species found in the middle part of the Paskenta group in its type district, and also farther north in Oregon and Washington. In the middle Paskenta group forms nearly related to *Simbirskites decheni* Pavlow and *Subastieria* Spath are also found. Higher in the section, in the lowest beds of the Horsetown group, these are replaced by *Neocraspedites* Spath. Only in their more mature stages of development can some of these genera be recognized; in their younger stages there is greater resemblance, particularly in *Simbirskites* and *Dichotomites*, so that the latter is here included in the family Simbirskitidae of Spath.

Polyptychitidae Spath, 1924

Polyptychites lecontei Anderson, n. sp.

(Plate 22, figure 1; plate 23, figure 1)

Shell large, robust, thickly costate, broadly umbilicate; section of whorl in adult stages subcircular, slightly broader than high, the ratio of height to breadth increasing with the growth of the shell, sides slightly flattened; umbilical walls abrupt, arising almost vertically; ribs numerous, branching from elongated umbilical bullae below the middle of the sides into three, four, or five smaller ribs; ribs rarely subdividing above; umbilical bullae elevated, narrow, rounded, not bearing tubercules, arising within the umbilicus, sloping at first backward, then vertical on the umbilical border, and thence inclining slightly forward before dividing; smaller costae rounded, nearly straight, crossing the ventral zone without interruption or flattening; interspaces broader than the costae; sides of shell crossed at intervals by broadly rounded grooves, arising at the umbilical border; suture lines as shown in the figures. The holotype (Calif. Acad. Sci. type Coll.), wholly septate, affords the following measurements: greatest diameter, 165 mm.; width of umbilicus, 58 mm.; height of whorl, 60 mm.; width of whorl, 62 mm.; umbilical ratio, 0.352:1.

This species resembles *"Olcostephanus" traski* (Gabb) but differs from it in some notable respects, as will be seen upon comparison of the figures. In its ribbing the ratio of the number of umbilical bullae to the peripheral ribs is about 1:3.7. Among European species its nearest analogue seems to be *Polyptychites polyptychus* Keyserling, figured by Pavlow; its horizon appears to be nearly the same—namely, middle or upper Valanginian.

The holotype was found in the Hamlin-Broad zone at Locality 113 (Calif. Acad. Sci.), 4 miles southwest of Ono, Shasta County, by Dr. E. J. Broad of San Francisco, who presented it to the California Academy of Sciences, with various other species and genera from the same zone and locality. It was found with *Polyptychites hesperius, Simbirskites broadi, Lytoceras saturnale, Lytoceras aulacum, Aspinoceras hamlini, Anahamulina vespertina, Acroteuthis shastensis, Belemnoteuthis (Conoteuthis) pacifica*, and many other species representing the upper part of the Paskenta group of the Shasta series in the Cottonwood district.

The horizon of this zone is stratigraphically about 500 feet beneath the lowest beds assignable to the Horsetown group in the Shasta series.

Polyptychites hesperius Anderson, n. sp.

(Plate 24, figures 1, 2)

Shell large, robust or massive, thick, with heavy branching ribs; section of whorl broadly triangular, with strongly converging sides; periphery relatively narrow, but rounded; umbilicus apparently not broad; umbilical nodes, or ribs, thick, arising on the umbilical wall, curving at first backward, but inclining forward on the sides, dividing below the middle into three, sometimes four, straight, rounded ribs which cross the periphery; sutures as shown in the figure.

The holotype of this species (Calif. Acad. Sci. type Coll.) was found by E. J. Broad at Locality 113 (Calif. Acad. Sci.), 4 miles southwest of Ono, Shasta County, at the head of Mitchell Creek. It is a large fragment representing a little less than a quarter of a whorl, with a portion of an inner whorl. It is septate throughout and accordingly is a part of an inner whorl. In its general form and character it recalls *Polyptychites sphaericus* von Koenen, but has fewer and heavier ribs. Its nearest west European analogue seems to be *Polyptychites lamplughi* Pavlow, although there are obvious differences. In the present species the section of the whorl is more

triangular, the umbilical ribs are thicker and stouter, and they divide at a higher level than in the English form.

The holotype was found associated with other forms of the genus, as given under *Polyptychites leconteï*, nov.

Polyptychites traski (Gabb)

Ammonites traski GABB, Paleont. Calif., vol. 1, 1864, p. 63, pl. 11, fig. 10; pl. 12, fig. 11 (septum); "Arbuckle Diggings," Shasta County.
Olcostephanus traski STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 18, 22; near Wilcox ranch, Tehama County, and (?) Riddle, Oregon.

From the description and figure of this species given by Gabb, although they are defective, it is evident that this form represents some species of *Polyptychites*, a genus not uncommon in the Paskenta group of the Shasta series. Various congeners of the species have been found in the upper part of this group, not only in the Cottonwood district, but in the Elder Creek-McCarthy Creek district. The holotype figured by Gabb was the property of the California Academy of Sciences and was in the care of the writer prior to 1906, but was lost in the San Francisco fire of that year. In section the younger whorls were nearly circular, becoming higher than broad in older stages. According to Gabb's description the surface was marked by numerous dichotomous ribs, but this is scarcely borne out by his figure, which shows the stout umbilical ribs branching into four or more costae below the middle of the sides. In this respect it is unlike any other of the group found in the Cottonwood district.

The locality of discovery given by Gabb is subject to much doubt, as elsewhere shown. It is believed to have been found in the Hamlin-Broad zone, which passes about 2 miles to the east of the old Arbuckle mine in western Shasta County. Its horizon would be, accordingly, in the upper part of the Paskenta group (upper Valanginian), as will be shown later. The occurrence of this species near the Wilcox ranch in Tehama County (Stanton, 1895, p. 18) appears to mark the same horizon as that of the Hamlin-Broad zone in the Cottonwood district.

The species is also recorded from Riddle, Oregon, by Stanton (1895, p. 22), and in both these areas it aids in the correlation of the beds with those of the Cottonwood district and the Paskenta group of the Shasta series.

In the Oregon area near Riddle, as will be shown, more than a single faunal zone appears to be represented. Stanton has given a list of 15 genera and with them has named at least eight species. Half of the forms given in the list may well be of Chico age, others undoubtedly represent the Horsetown group, and some are from the Paskenta group, including the present species and *Aucella crassicollis*.

Simbirskites broadi Anderson, n. sp.

(Plate 22, figures 2, 3; plate 28, figures 1, 1a)

Shell not large, inflated, broadly umbilicate, section of whorl reniform, broader than high, in younger stages depressed; umbilical walls abrupt, sloping above; umbilical ribs stout, arising on the wall of the umbilicus with a slight backward slant, then rising to near the middle of the side where it forms a tuberculate node from which it divides normally into three (rarely two) peripheral ribs which cross the ventral area without interruption; ribs rounded, inclined forward on the upper part of the shell, separated by rounded interspaces, which are broader between the rib clusters than between the ribs themselves. This species appears to have its nearest analogue in *Simbirskites decheni* Pavlow (not Roemer), from the Neocomian of England, which Spath appears to regard as synonymous with *"Olcostephanus" kleini*

Neumayr and Uhlig. The species is represented in the collections of the California Academy of Sciences by a well-preserved fragment and a partial mold of the same, from which the figures were made. The holotype (Calif. Acad. Sci. type Coll.) has the following dimensions: greatest diameter, 75 mm.; width of umbilicus, 33 mm.; height of whorl, 25 mm.; width of whorl, 36 mm.; umbilical ratio, 0.44:1.

This example was found at Locality 113 (Calif. Acad. Sci.) and was presented to the California Academy of Sciences with many other fossils by Dr. E. J. Broad of San Francisco, for whom the species is named in recognition of this courtesy and of his interest in the work of the Academy of Sciences.

A small fragmentary example of this genus, possibly representing this species, was found on McCarthy Creek, Tehama County, in "Zone N," with *Neocomites jenkensi*, nov.

Subastieria Spath, 1921, p. 32

Genotype, *"Olcostephanus"* (*Astieria*) *sulcosus* Pavlow

Subastieria chanchelula Anderson, n. sp.

(Plate 22, figures 4, 5)

Astieria cf. *astieri* (d'Orbigny) ANDERSON, Geol. Soc. Am., Bull., vol. 44, 1933, p. 1250; "Zone N," McCarthy Creek, Tehama County.

Shell small, spheroidal, coronate, with deep and narrow umbilicus; section of whorl reniform, broader than high; umbilical walls abrupt, surmounted by small, elongated bullae, scarcely tuberculate; sides densely costate, the costae arising on the umbilical wall, inclining forward, forming the umbilical bullae; smaller costae branching from these in groups of two or three, crossing the periphery without interruption. The holotype (Calif. Acad. Sci. type Coll.) was obtained at Locality 113 (Calif. Acad. Sci.) in the Hamlin-Broad zone, where it was associated with *Polyptychites lecontei*, *Simbirskites broadi*, and many other Paskenta species. The same species was found on McCarthy Creek, Tehama County, associated with *Neocomites jenkinsi*, *Thurmannia paskentae*, *Aucella nuciformis* Pavlow, and other species of upper-middle Valanginian age.

Neocraspedites Spath, 1924

Neocraspedites aquila Anderson, n. sp.

(Plate 25, figures 1, 2, 3; plate 68, figure 4)

Shell large, discoidal, flattened on the sides, though little compressed; rather broadly umbilicate, the umbilicus having abrupt walls, rounded on the border; sides closely costate with branching ribs; umbilical ribs arising on the walls, or at the suture, inclining slightly backward, but on the umbilical border describing a broad curve, above which they divide a little below the middle of the side, inclining then strongly forward; above the middle of the side re-dividing into two or three smaller costae, all crossing the periphery without interruption; suture lines not fully known; the relatively large first lateral lobe resembling that of *Neocraspedites tenuis* (von Koenen). The holotype (Calif. Acad. Sci. type Coll.) consists of a fragment, about a quarter of a whorl, and a mold of the same specimen, including a large part of the umbilicus. This, and two larger and more complete, but somewhat crushed, examples were found on Eagle Creek, near Ono, Shasta County, in the Ono zone in the basal beds of the Horsetown group. The larger example measures 8 inches in diameter and has a maximum thickness of 1.75 inches. The species appears to be closely

related to "*Craspedites*" *tenuis* (von Koenen), which this author regards as of Hauterivian age. Spath cites other species of this genus in the lower Hauterivian zones at Speeton, England. The holotype has the following dimensions (partly estimated): greatest diameter, 185 mm.; width of umbilicus, 66 mm.; height of whorl, 55 mm.; thickness of whorl, 60 mm.; umbilical ratio, 0.356:1.

The species is found at Locality 1353 (Calif. Acad. Sci.), associated with *Lytoceras traski* nov., *Phylloceras occidentale* nov., *Acrotaulhis kernensis* nov., *Inoceramus colonicus* nov., and many other molluscan species of Hauterivian age.

Neocraspedites rectoris Anderson, n. sp.

(Plate 23, figure 2)

Shell of moderate size, discoidal angustumbilicate, moderately inflated, umbilical walls steep, rounded above, merging with the slightly convex sides; sides with many costae; umbilical ribs arising on the walls, inclined backward, curving strongly on crossing the border, swelling slightly near the middle of the side, and branching here into four, sometimes five, finer costae, all with forward inclination crossing the side, and also the periphery, without interruption; suture line only imperfectly exposed. The holotype of the species (Calif. Acad. Sci. type Coll.) was found at the mouth of Rector Creek, near Ono, Shasta County, about 50 feet beneath the bed containing the preceding species. It appears to belong to the group of *N. semilaevis* (von Koenen), although occurring in somewhat younger beds, which are regarded as lower Hauterivian in age. Von Koenen refers his species with some doubt to the lower Valanginian of Osterwald.

The holotype of the present species consists of an inner coil, septate throughout, having the following dimensions: greatest diameter, 53 mm.; width of umbilicus, 11 mm.; height of whorl, 25 mm.; greatest thickness, 25 mm.; umbilical ratio, 0.208:1.

Neocraspedites signalis Anderson, n. sp.

(Plate 26, figure 1)

Shell rather large, discoidal, slightly inflated, section of whorl flatly semi-elliptical, sides slightly flattened; umbilicus of moderate width, walls abrupt, rounded on the border; ventral border rounded; sides numerously costate, the ribs arising on the umbilical walls as coarse ridges, inclining at first backward, but above the umbilical border bending gently forward, then dividing into two or three rather straight costae, which are rather fine and rounded, and which cross the periphery without interruption; suture line partly shown in the figure. The holotype (Calif. Acad. Sci. type Coll.) was found by Mr. M. A. Wilcox on the eastern portion of his ranch, 5 miles north of Paskenta, Tehama County. According to his statements it was found above the zone containing *Aucella crassicollis*, which also contains *Dichotomites*, *Berriasella*, and *Bochianites paskentaensis*, nov., but its more exact position is not yet known. The holotype has the following dimensions: greatest diameter, 143 mm.; diameter of umbilicus, 56 mm.; height of whorl, 55 mm.; thickness of whorl, 36 mm.; umbilical ratio, 0.392:1.

The holotype was not found associated with any other recognized form, although it was not far from the position occupied by the foregoing and the following species. Both are thought to represent the lower beds of the Horsetown group in the district between McCarthy Creek and Elder Creek, Tehama County; they aid, therefore, in the correlation of these beds with those of the Ono zone in the Cottonwood district, Shasta County. Species of this genus have been found near Garzas Creek, on the east flank of the Diablo Range, on the west border of the San Joaquin Valley.

Neocrospedites wilcoxi Anderson, n. sp.

(Plate 26, figure 2; plate 27, figure 4)

Shell large, discoidal, moderately inflated, rounded on the periphery; umbilicus moderately broad, walls steep, abruptly rounded on the border to meet the flattened sides; section of whorl elliptical, sides sloping gently to the rounded periphery; sides rather weakly costate, marked by a few slightly sinuous, inconspicuous transverse grooves and costae; costae arising on the umbilical walls as low ribs and hollows, inclining at first backward, then forward on the umbilical border, where they tend to divide; both costae and grooves rising on the sides with a slight forward inclination, cross the ventral zone without interruption; suture line partly shown in the figure. The holotype (Calif. Acad. Sci. type Coll.) consists of a little less than half a whorl, septate throughout, which permits the following measurements (in part): greatest diameter (est.), 138 mm.; width of umbilicus (est.), 45 mm.; height of whorl, 53 mm.; thickness of whorl, 43 mm.; umbilical ratio, 0.326:1. This specimen was found by Mr. M. A. Wilcox on the eastern portion of his ranch, 5 miles north of Paskenta, Tehama County. According to his statement, and as shown by the lithological character of the matrix, its horizon is not far from that of the preceding species, although it may be somewhat higher. It is believed to represent the lower part of the Horsetown group in the district between McCarthy Creek and Elder Creek, Tehama County.

Dichotomites tehamaensis Anderson, n. sp.

(Plate 28, figure 2; plate 30, figure 6)

Shell of moderate size, moderately robust, narrowly umbilicate, finely costate in young stages, almost smooth in mature stages; shell bearing a few irregularly spaced constrictions; umbilicus somewhat funnel shaped, deep, with steeply sloping walls, rounded on the border; periphery rounded; umbilical ribs about 40, rather weak, branching into three or four minor riblets near the middle of the side, inclined strongly forward; in older stages of growth all the ribs become almost obsolete, particularly on the inner part of the whorl. The holotype (Calif. Acad. Sci. type Coll.) affords the following measurements: greatest diameter, 73 mm.; width of umbilicus, 17 mm.; height of whorl, 33 mm.; thickness of whorl, 28 mm.; umbilical ratio, 0.233:1.

This species occurs in "Zone M_4" of the Paskenta group on the Wilcox ranch, 5 miles north of Paskenta, Tehama County. Its horizon is at or near the middle of the Paskenta group and also near the middle of the Valanginian stage. The holotype was donated to the California Academy of Sciences by Mr. R. B. Fripp of Corning, to whom the Academy is indebted for other characteristic species from this district.

Dichotomites gregaeni Anderson, n. sp.

(Plate 28, figures 3, 4)

Shell of medium size, discoidal, moderately compressed, narrowly umbilicate, rather coarsely costate, periphery narrowly rounded; interior of umbilicus ribbed, walls abrupt, nearly vertical, crossed by the interior ribs which are inclined backward; after passing the umbilical border these are inclined forward on the lower half of the side; major ribs branching near the middle of the side into two in young shells and into three in mature shells; the minor costae are inclined forward on approaching the periphery which they cross without interruption; in mature shells the major ribs often become pinched into narrow ridges. Normally, there are three branches from the major ribs. The holotype of this species (Calif. Acad. Sci. type Coll.) was

found with 10 other examples at Locality 1349 (Calif. Acad. Sci.) in "Zone M_3" on the Wilcox ranch, 5 miles north of Paskenta, Tehama County. It permits of the following measurements: greatest diameter, 50 mm.; width of umbilicus, 12 mm.; height of whorl, 23 mm.; thickness of whorl, 19 mm.; umbilical ratio, 0.250:1.

The species appears to belong to the group of *Dichotomites fragilis* (Pavlow, not Trautschold), said to have come from bed "D-4" of the Speeton section, England. All specimens of this species were found associated with *Aucella crassa*, *A. crassicollis*, *Berriasella* sp., and *Bochianites paskentaensis* nov. The paratype (Calif. Acad. Sci. type Coll.) has the following dimensions: greatest diameter, 46 mm.; greatest thickness, 15 mm.

The species is named in recognition of the aid given by Mr. A. I. Gregersen of the Texas Company, in making the collections, and in the preparation of traverses across the Cretaceous sections in western Tehama County.

Dichotomites burgeri Anderson, n. sp.

(Plate 28, figure 5)

Shell of medium size, discoidal, compressed, narrowly umbilicate, finely costate; periphery narrowly rounded; umbilical walls abrupt, smooth or slightly costate; major ribs arising on the umbilical walls, nearly straight above its borders, inclined forward, and dividing into four smaller costae at or above the middle of the sides; costation tending to become weak or obsolete on the body-chamber. The holotype (Calif. Acad. Sci. type Coll.) has the following dimensions: greatest diameter, 60 mm.; width of umbilicus, 18 mm.; thickness of whorl, 18 mm.; umbilical ratio, 0.266:1.

This species differs from the preceding in having finer costae and a somewhat compressed section of whorl, and in its higher point of branching of the ribs. The holotype was obtained at Locality 1349 (Calif. Acad. Sci.) in "Zone M_2" of the Paskenta group on the Wilcox ranch, 5 miles north of Paskenta, Tehama County. It was found with the preceding, and with the same associates. The species is named in recognition of interest and aid given by Mr. R. W. Burger of the Texas Company in making traverses across the Shasta series in western Tehama County, and the making of important fossil collections in these districts.

Dichotomites trichotomous (Stanton)

Olcostephanus (Polyptychites) trichotomous STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 78, pl. 16, fig. 1; 2 miles south of Lowry's, "in the uppermost layers of the Knoxville beds" (upper part of the Paskenta group).

As this species seems closely related to the preceding and following forms, it is placed with them in *Dichotomites* Spath. Most of these forms occur in nearly the same horizon in the upper part of the Paskenta group. In the collections of the California Academy of Sciences there are numerous examples of this genus from the Wilcox ranch 5 miles north of Paskenta in the zone of *Aucella crassicollis* and *A. crassa*, some of which closely resemble the figure of the present species as illustrated by Stanton (1895, pl. 16, fig. 1). On the Wilcox ranch the zone of this and the associated forms is near the top of a thick sequence of beds dominated by rugose, heavy-shelled species of *Aucella*, among which *A. crassicollis* is somewhat rare. These beds have a thickness of about 1200 feet, beneath which are plant-bearing beds.

Dichotomites oregonensis Anderson, n. sp.

(Plate 30, figure 4)

Shell small, discoidal, compressed, angustumbilicate, sides sloping toward the periphery, densely costate; primary costae arising on the umbilical border in con-

spicuous bullae, passing outward nearly normal to this border, but dividing below the middle of the side into two, three, or more finer costae, which have a strong forward slant, crossing the periphery without interruption, although weakened in the ventral zone. Periphery narrowly rounded. The holotype and two additional examples were obtained by E. L. Packard at Locality 268 (Oregon State Coll.), about a mile east of Riddle, Oregon, and are the property of the Oregon State College. The holotype has the following dimensions: greatest diameter, 23 mm.; width of umbilicus, 3 mm.; greatest thickness, about 7 mm. Although this species has a smaller umbilical ratio than most members of this genus thus far found, it seems to belong to the group of *Dichotomites fragilis* (Pavlow, not Trautschold), which according to Spath represents a Valanginian horizon (bed D-4) at Speeton, England. This form was found associated with *Neocomites riddlensis*, *Phylloceras trinitense*, and *Pecten* (*Syncyclonema*) sp. in a hard shaly sandstone in the first ridge east of Riddle, in strata overlying thick beds of conglomerate, containing in their upper part *Aucella inflata*, and *Aucella lahusenì*, abundant in the lower part of the Paskenta group in California. The horizon of this species can hardly be younger than lower Hauterivian and is believed to be upper Valanginian, corresponding to the horizon of *Dichotomites tehamaensis* in the McCarthy Creek district in California.

Dichotomites mutabilis (Stanton)

Olcostephanus (*Simbirskites*) *mutabilis* Stanton, U. S. Geol. Surv., Bull. 133, 1895, p. 77, pl. 15, figs. 1, 2, 4, only; Shelton's ranch, 5 miles north of Paskenta, Tehama County. (Not *Amm. mutabilis* Sowerby, Lower Cretaceous of England; not *Amm. mutabilis* d'Orbigny, Jurassic of France).

From the figures and description of this species given by Stanton (1895, p. 77, pl. 15, figs. 1, 2, 4), one gets the impression that the shell is compressed and disk-like; it is true that compressed forms are plentiful in the zone of the holotype. However, among 40 examples of this genus obtained from this zone by the writer, as many as three species were recognized, none of which were much compressed except by rock pressure, and they do not support the view of great variability claimed for any species among this number. Changes in the character and number of the ribs can be seen in some forms at different stages of growth, but it seems possible that Stanton's examples included more than a single species. One of these examples should be selected as the holotype, and for this we may accept the first. Stanton compares his species to "*Olcostephanus*" *discofalcatus* Lahusen, which Spath regards as *Craspedodiscus*. Nevertheless, after a careful comparison of a large number of examples, both forms figured by Stanton appear to belong to the group of *Dichotomites fragilis* (Pavlow), as do many others obtained from the same zone. Spath (1924, table opp. p. 80) refers Stanton's species to a low position in the stratigraphic column—namely, that of *Subcraspedites stenomphalus* (Pavlow)—and therefore to a low Valanginian horizon, although most of the Polyptychitidae at Speeton are placed higher in the column. The horizon of the present species, like that of the next three species to be discussed, is not lower than middle, and may better be regarded as upper Valanginian, corresponding to the horizon of the Hamlin-Broad zone in the Cottonwood district of Shasta County.

Spiticeras Uhlig 1903

Spiticeras duncanense Anderson, n. sp.

(Plate 27, figures 1, 2)

This species appears to belong to the group of *Spiticeras ducale* (Matheron), as figured by Kilian (1910, pl. 2, fig. 4), found in the zone of *Thurmannia boissieri*

(Pictet). The shell is rather large, broadly umbilicate, finely costate, but little involute; section of whorl semi-elliptical; having about 250 costae to the whorl, arising partly in the umbilical bullae, from which they separate into two or three thread-like, somewhat sinuous ribs, at first inclining forward, then rising normally on the side, then slightly backward, and again forward, crossing the periphery without interruption; the major ribs, below the umbilical bullae, inclining forward in the dorsal zone; between the umbilical bullae, four to eight simple, single costae arising in the dorsal zone parallel to the others; suture lines not yet known. A row of minute tubercules are visible on either side of the ventral zone on each second or third rib. The holotype (Calif. Acad. Sci. type Coll.) was found at Locality 1665 (Calif. Acad. Sci.) on Duncan Creek, three-quarters of a mile north of the Ono-Beegum road. It consists of a little less than one-quarter of a whorl; as nearly as can be estimated, the complete example had the following dimensions: greatest diameter, 147 mm.; width of umbilicus, 88 mm.; height of whorl, 33 mm.; thickness of whorl, 33 mm. This example was found in a hard, dark calcareous concretionary block, similar in character to the overlying beds, and mingled with others in a brecciated zone, brought to the surface by faulting from possibly lower beds. With it were found the holotype of *Neocomites russelli* nov. and a large fragment of *Crioceras latum* Gabb. This occurrence seems to represent the lowest fossil-bearing bed yet found in the Shasta series in the Cottonwood district, although lower beds are exposed farther to the south.

Hoplitidae Hyatt, emend. Spath

In the Lower Cretaceous of California and Oregon there are few Hoplitids as compared with contemporary deposits in western Europe or in western Argentina. Forms with sulcate, or even flattened, periphery are not abundant in the Paskenta group, and they disappear before the close of the Valanginian, although supposedly derivative forms appear in the middle part of the Horsetown group. There are no known representatives of either *Leopoldia* or *Acanthodiscus*, and few of either *Thurmannia* or *Steueroceras* (s. s.). In restricted areas in the middle or upper part of the Paskenta group are found a few berriasellids of various kinds, especially in the district south of the delta where the fauna is dominated by heavy-shelled forms of *Aucella*. Few hoplitids have been found in the Cottonwood district north of the delta, as compared to the number at the south; only two examples have been found in the Cottonwood district, and three species in the Riddle district in Oregon, all of which have come from the Paskenta group. Most of them are regarded as either *Berriasella* or *Neocomites*. In all these forms the periphery is rounded, or only slightly flattened. The ribs are comparatively simple, or but slightly flexed, and, when divided, the branching occurs high on the side of the whorl, as in the berriasellids. *Neocomites* is found in the Paskenta group in the districts north and south of the delta in California, and in the Riddle district in Oregon, in beds of this group, although not the same species.

Thurmannia has been found both north and south of the delta area in California, but none in the district about Riddle, nor in any part of the Horsetown group. If derivatives of any of these types occur in strata later than the Paskenta, they must be among the Horsetown forms here grouped under Parahoplitidae Spath, but they do not appear before late Hauterivian time, and then not in great numbers. In the middle part of the Horsetown group (Aptian) appear *Parahoplitoides* Spath, and a little higher *Parahoplites* Anthula and *Acanthoplites* Sinzow. The latter genus continues into the Hulen beds (lower Albian), and with them, possibly belonging in the same lineage, forms of *Cheloniceras* and *Douvilleiceras*.

In the Perrin zone, somewhat higher in the Hulen beds, there are many species of *Sonneratia* and a few of *Cleoniceras*, included by Whitehouse in Cleoniceratidae. The relation of these to Hoplitidae is not clear, although like *Beudanticeras* and others that follow they may be regarded as derivatives of hoplitid types.

The hoplitids (*s. s.*) now known from the Paskenta group in California and Oregon may be summarized as follows:

North of the delta, California	*South of the delta*
Upper Valanginian	
Thurmannia jupiter nov.	*Berriasella angulata* (Stanton)
	B. sp., nov.
	Bochianites paskentaensis nov.
Lower, or Middle Valanginian	
Neocomites russelli nov.	*Neocomites jenkinsi* nov.
N. sp. nov.	*N. stippi* nov.
	Thurmannia paskentae nov.
In Oregon	*Berriasella crassiplicata* (Stanton)
	B. sp. nov.
Berriasella ? hyatti (Stanton)	*Bochianites paskentaensis* nov.
Neocomites riddlensis nov.	
Lytioceras packardi nov.	

None of the forms possibly derivative from Hoplitidae can be confidently traced to any of the species in the foregoing list, whereas most of the forms included under Parahoplitidae have near analogues in the Lower Cretaceous of southwest Asia or in contemporary deposits in Europe.

Thurmannia Hyatt

Thurmannia paskentae Anderson, n. sp.

(Plate 29, figures 3–6)

Two small examples and a large fragment of *Thurmannia* were found with *Neocomites jenkinsi* nov. in "Zone N" on McCarthy Creek, southern Tehama County. The larger of the more complete examples measures 12 mm. in diameter, 6 mm. in greater thickness, and the width of the umbilicus is 3.2 mm. The shell is flattened on the sides but rounded on the ventral and umbilical borders; shell bearing about 50 to 52 slightly flexed costae that divide a little above the middle of the side into two branches; ventral zone showing a median depression in which the ribs are slightly offset; costae bearing terminal nodes at the borders of the ventral zone; suture line not well exposed, although the lateral lobe is broad, bearing three stout branches, others not shown. The holotype (Calif. Acad. Sci. type Coll.) was found at Locality 3398 (Calif. Acad. Sci.) on McCarthy Creek, above the middle of the Paskenta group, and therefore in an upper Valanginian horizon. The species seems to be nearly related to *Thurmannia chicoensis* Weaver (1931, p. 462, pl. 56, figs. 345, 355) from the lower Valanginian beds of southern Mendoza, western Argentina, although direct connection with these beds can hardly be shown to have existed. On McCarthy Creek its zone lies above the principal part of the *Aucella*-bearing beds, although not above the range of the genus.

Thurmannia jupiter Anderson, n. sp.

(Plate 31, figure 1)

Shell large, latumbilicate, little involute, moderately inflated, closely costate, without tubercules, but having elongated bullae on the umbilical margin; walls of the

umbilicus abrupt, rounded above, but curving rapidly to the flattened sides; section of whorl semi-elliptical, higher than broad, narrowing toward the rounded periphery; strong umbilical ribs arising at the whorl suture, inclining strongly backward, thickened to bullae on the margin; ribs branching from these into two, or rarely into three, smaller, rounded, sinuous ribs; between these groups are interpolated a few simple ribs; other intermediary ribs arise at intervals above the middle of the sides; all ribs crossing the ventral zone without interruption and with a forward bend; the 60 or more costae on the periphery are about three times the number occurring on the umbilical border; the interspaces between the ribs are broader than the ribs, and are concavely rounded; in adult stages the ribs become heavier and more widely spaced; the sutures are hoplitid, although not clearly exposed.

This species greatly resembles *Thurmannia boissieri* (Pictet), as figured by Uhlig (1903, pl. 30), and it may be its nearest California analogue. It differs from this species in having a more rounded ventral border, in its more elongated umbilical bullae, and its fewer intermediary ribs arising above the middle of the sides.

The holotype (Calif. Acad. Sci. type Coll.) was found in a calcareous concretion buried in dark shale in the Hamlin-Broad zone 3 miles southwest of Ono, Shasta County, and about 1600 feet above the local base of the Paskenta group. Its stratigraphic position appears to be near that of *Dichotomites*, *Berriasella*, and *Aucella crassicollis* on the Wilcox ranch and on McCarthy Creek, Tehama County, and therefore aids in the correlation in the two districts.

BERRIASELLIDAE Spath 1924

Berriasella Uhlig 1903

Berriasella angulata (Stanton)

Hoplites angulatus STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 80, pl. 18, figs. 3, 4; Shelton's ranch, 5 miles north of Paskenta, Tehama County.

Concerning this species Stanton says (in part):

"This species is evidently related to *Hoplites storrsi*, but its whorls are proportionally somewhat more convex, its sculpture is relatively coarser, with broader and more strongly curved ribs, and the border of the umbilicus is more angular."

Stanton also compares it to a specimen from Speeton, England, figured by Pavlow, which the latter regarded as "*Hoplites*" *amblygonius* Neumayr and Uhlig. According to Burckhardt (1930, tables 6, 10) "*Hoplites*" *storrsi* Stanton should be regarded as a *Berriasella*, and seems to belong to the group of *Berriasella calisto* (d'Orbigny). This observation should also apply to "*Hoplites*" *angulatus* Stanton, and to other forms described from the lower part of the Paskenta group. The association of this species with *Aucella crassa*, *A. crassicollis*, "*Simbirskites*" *mutabilis* Stanton, and *Bochianites*, and other forms of *Berriasella* indicate a horizon not higher than the upper part of the Paskenta group, and therefore not higher than Valanginian.

Berriasella crassiplicata (Stanton)

Hoplites crassiplicatus STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 81, pl. 18, figure 8; 3 miles north of Paskenta, Tehama County, associated with *Aucella crassicollis*.

Stanton compares this species with "Russian Lower Volgian species '*Hoplites*' *rjasensis* Lahusen," as figured by Nikitin. However, as noted by Stanton, the form is perisphinctoid, and is characterized by a

"Surface ornamented by relatively large, distant ribs that arise on the edge of the umbilicus, and nearly all bifurcate after passing over about two-thirds of the distance to the periphery, on which they are interrupted."

A fragment of this species was found by the writer at approximately the horizon described by Stanton on McCarthy Creek; it is here associated with *Neocomites jenkinsi* nov., *Thurmannia paskentae* nov., and *Aucella piriformis* Lahusen. Its berriasellid characters are clearly seen in its branching ribs and in its flattened abdominal surface and its umbilical features.

Berriasella ? hyatti (Stanton)

Hoplites hyatti STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 79, pl. 16, fig. 2; 2 miles southwest of Riddle, Oregon.

The hoplitid character of this species can hardly be questioned, but to what section of "*Hoplites*" it should be assigned is less easy to determine. According to Stanton's account, the species is characterized by an

"abdomen slightly flattened, except on the last third of the outer volution; surface marked by numerous slightly curved ribs, the most of which bifurcate on the outer third of the volution and cross the abdomen, though not quite so prominent there as on the sides."

As may be seen in the drawing by Stanton (1895, pl. 16, fig. 2), the periphery on the last whorl appears narrow, if not angulate, recalling the early mature stages of the following species, *Lyticoceras packardi*. The association of the present species with *Aucella crassicollis* indicates its age as Valanginian, probably somewhat lower in the section than the preceding. Stanton (1895, p. 79) states that the

"species is related to *H. tenochi* Felix and *H. ripei* Felix, from the Neocomian near Tlaxiaco, in the State of Oaxaca, Mexico, . . . also that its nearest relative among Knoxville forms is *Hoplites storrsi*." . . .

As all these forms seem referable to *Berriasella*, the present form probably belongs to this genus. It appears from Stanton's account that it was found in the upper part of a thick sequence of conglomerate bordering the Cow Creek Valley on the west, which is here regarded as representing the Paskenta group.

Lyticoceras Hyatt

Lyticoceras packardi Anderson, n. sp.

(Plate 31, figures 2, 3, 4, 5)

Shell of moderate size, flatly discoidal, narrowly umbilicate, sides of the cast mostly smooth on the lower half, or showing only the costal lines, but strongly costate on the outer part; costae branching near the middle of the side, more clearly visible on young adult shells; sutures hoplitid in character, but only partially exposed, showing stout tripartite lateral lobes; periphery narrow, sub-angular, not bordered by visible nodes; ventral zone gently rounded in young stages up to a diameter of 40 mm., after which stage the periphery becomes more ridge-like, and, at a diameter of 60 mm., the ribs on the two sides of the shell unite chevron-like on its median plane.

In its younger stages the shell possesses neocomitid characters in its small umbilicus, flattened periphery, and numerous flexuous costae, but in more mature stages it develops the features of *Lyticoceras* in its general form, costation, and ridge-like periphery, as in *Lyticoceras regale* (Bean).

The holotype and other figured specimens are at the Oregon State College and were collected by E. L. Packard at Locality 268 (Oregon State Coll.), a mile east of Riddle, Oregon. They were found in a stratum of shaly sandstone associated with *Neocomites riddlensis*, *Dichotomites oregonensis*, and *Phylloceras trinitense*; this

stratum is underlain by a thick sequence of conglomerates carrying in the upper part species of *Aucella*, of the lineage of *Aucella crassicollis* Keyserling.

The holotype affords the following measurements: greatest diameter, 68 mm.; diameter of umbilicus, 6.5 mm.; height of whorl, 34 mm.; thickness, 15 mm. As many as eight specimens of this species were obtained from the same stratum.

The resemblance of this species to *Subsaynella* Spath (1921, p. 31) is interesting as suggesting a possible relationship of the latter to a Valanginian Hoplitid stock.

NEOCOMITIDAE Spath 1924

Neocomites Uhlig

Neocomites jenkinsi Anderson, n. sp.

(Plate 29, figure 1)

Steueroceras jenkinsi ANDERSON, Geol. Soc. Amer., Bull., vol. 44, 1933, p. 1259; Zone N. McCarthy Creek, Tehama County.

Shell of medium size, evolute, discoidal, densely costate, having at the umbilical border about 80, and at the periphery of the last whorl about 140, fine rounded costae, which divide sometimes below, and sometimes above the middle of the side; ribs arising on the umbilical wall, forming a slight swelling on crossing its border, flexuous on the side, curving slightly forward near the periphery; ventral zone slightly flattened, crossed by the uninterrupted costae; umbilical walls steep, rounded on the border. The following measurements are taken from the holotype: greatest diameter, 110 mm.; diameter of umbilicus, 32 mm.; height of whorl, 36 mm.; width of whorl, 23 mm.

Two good examples and many fragments of the species have been found with various other Paskenta species. The smaller and more perfect example has a portion of the shell preserved, showing the rounded ribs, separated by interspaces broader than the ribs. The holotype (Calif. Acad. Sci., type Coll.) was obtained at Locality 2398 (Calif. Acad. Sci.), Zone N, on McCarthy Creek, Tehama County. This example resembles *Steueroceras permulticostatum* (Steuer) from eastern Argentina (Nequen and Mendoza, Weaver) (1931, p. 441). It was found in the same bed with *Thurmannia paskentae* nov., *Subastieria* sp., *Lytoceras* cf. *traski* nov., *Aucella terebratuloides* Lahusen, *Aucella nuciformis* Pavlow, and numerous plant remains. Its stratigraphic position is near the middle of the Paskenta group (middle Valanginian), which is near the position assigned to what may be its congener in the Lower Cretaceous of Argentina. Because of its resemblance to species of "*Steueroceras*" described by Gerth (1925, p. 473), this species was first thought to represent this genus, but it differs from the genotype, *Steueroceras transgrediens* (Steuer), as interpreted by Cossmann, Uhlig, and Spath, in having a non-sulcate periphery. It would seem, therefore, according to Spath's interpretation, that the species here described belongs more probably to *Neocomites* Uhlig. Other species of the genus are not uncommon in the Paskenta group of California and Oregon. In all cases except one, they are associated with *Aucellae*, of the group represented by *Aucella crassicollis*, and by other forms indicating a horizon not higher than middle Valanginian.

Neocomites russelli Anderson, n. sp.

(Plate 27, figures 3, 3a)

Shell of moderate size, discoidal, costate; umbilicus moderately broad, funnel-form, sides sloping, rounded on the borders; periphery rounded or slightly flattened on the latter part of the whorl; major ribs arising on the umbilical walls, sinuous

on the sides, crossing the periphery without interruption; secondary ribs interpolated between the others, not extending into the umbilicus; total number of ribs (est.), about 50 to the whorl; suture lines unknown.

The holotype of this species (Calif. Acad. Sci. type Coll.), as found by R. Dana Russell at Locality 1665 on Duncan Creek, associated with *Crioceras latum* Gabb, *Lytoceras* cf. *traski*, and *Spiticeras duncanense* nov., has the following dimensions: greatest diameter, 73 mm.; width of umbilicus, 13 mm.; height of whorl, 32 mm.; thickness of whorl, 20 mm.

This species, although thicker in section and possessing fewer ribs, seems to belong to the group represented by *Neocomites stippi* nov. It represents the lowest fossil-bearing bed exposed in the Shasta series of the Cottonwood district, although not the lowest bed exposed in this area. This is one of the two examples of *Neocomites* that have been found in this district.

Neocomites stippi Anderson, n. sp.

(Plate 29, figure 2)

Two fragmentary examples of a hoplitid species were found in the upper part of the "*Aucella crassicollis* zone" on McCarthy Creek, associated with *Aucella crassa*, *Aucella crassicollis*, *Acroteuthis onoensis*, *Lytoceras saturnale* nov., and other species. Although incomplete, these examples are sufficiently well preserved for generic determination and for partial description. They belong to the group represented by *Hoplites* (*Neocomites*) *angulicostatus* (d'Orbigny), although they have some characters of "*Berriasella*" *beneckei* (Steuer) from the Valanginian of western Argentina.

The section of the whorl is flatly elliptical and slightly inflated; sides costate, the ribs arising on the umbilical wall, forming on its borders elongated nodes from which some of them branch; others branch from above the middle of the side, all curving gently forward and crossing the ventral zone with a slight forward curve; umbilicus moderately wide, with abrupt walls; sutures closely crowded, showing stout, much-divided lobes and saddles; lateral lobe somewhat extended, trifid, each branch terminating in long, slender digitoid points.

The holotype (Calif. Acad. Sci. type Coll.) was found by Mr. Thomas Stipp on the south bank of McCarthy Creek, about 1,000 feet beneath the zone containing *Neocomites jenkinsi*. The horizon is that of the lower part of the Paskenta group (Infra-Valanginian) of the McCarthy Creek section.

The nodes on the umbilical borders, more prominent on the shell than on the cast, somewhat resemble Kilian's (1910, pl. 1) figure of *Thurmannia boissieri* (Pictet).

Neocomites neocomiensis (d'Orbigny)

(Plate 33, figures 2, 2a)

Ammonites neocomiensis D'ORBIGNY, Paleont. Francaise, vol. 1, 1840, p. 202, pl. 59, figs. 8–10; lower beds of the Neocomian terrain, central France.

Only a single specimen sufficiently well preserved for illustration has been found in the Lower Cretaceous of California; this was obtained by N. L. Taliaferro in the Waltham Creek Valley, on the southwest quarter of section 17, T. 20 S., R. 13 E., M. D. M., north of the Coalinga-Priest Valley road. In this example the shell is compressed, discoidal, ornamented by transverse costae, 74 in number, a little flexuous, bifurcating from small nodes on the umbilical border, and again dividing near the middle of the side into two, three, or more costae as counted near periphery; sides slightly inflated, thickest in the lower one-third of the side, sloping toward the periphery; costae interrupted on the ventral zone, which is slightly excavated, and bordered by minute costal nodes; maximum width of ventral zone, 2 mm.; maximum

diameter, 20 mm.; width of umbilicus, 5.5 mm.; height of whorl, 11 mm.; greatest thickness, 6 mm.

This example was found associated with *Acroteuthis macarthyensis* nov., *Acroteuthis* n. sp., *Aucella crassa*, *A. inflata*, *A. crassicollis*, and a few other species, in the basal conglomerate of the Shasta series (Paskenta group), marking a distinct unconformity between this series and the underlying Knoxville sandy shales.

Neocomites riddlensis Anderson, n. sp.

(Plate 30, figures 1, 2, 3, 4)

Shell of moderate size, discoidal, compressed, with small umbilicus; ventral zone rather broad, flattened, angulated on its borders; sides mostly smooth below but costate on the upper half, with about 38 to 42 rounded costae which carry at their termini small elongated tubercules; costae separated by concave interspaces, somewhat broader than the ribs; costal lines flexed, curving strongly forward below the periphery, crossing the ventral zone without interruption, and with a slight forward bend; costal lines terminating at the umbilical border in umbilical bullae having a slight backward slant; suture lines not well exposed, but tripartite, and showing hoplitid characters.

The young shell of this species, with a diameter less than 30 mm., is nearly smooth, having only costal lines and faint sub-peripheral costae, terminating in small elongated tubercules on the ventral border; the flattened ventral zone is nearly smooth, the umbilicus small with abrupt walls. In its young stages this shell has the form of *Neocomites neocomiensis* d'Orbigny, although it has a smaller umbilical ratio. In examples of a diameter of more than 50 mm., the umbilical bullae begin to appear, from which the costal lines radiate in small groups.

The holotype and paratypes of this species are the property of the Oregon State College and were obtained by E. L. Packard at Locality 268 (Oreg. State Coll.), about a mile southeast of Riddle, Oregon, in beds that seem referable to the upper part of the Paskenta group (Upper Valanginian) as known in California. The holotype has the following dimensions: greatest diameter, 78 mm.; diameter of umbilicus, 22 mm.; height of whorl, 36 mm.; thickness of whorl, 21 mm.; umbilical ratio, 0.282:1. In form and sculpturet he species resembles *Neocomites montanus* Uhlig (1903, p. 249, pl. 90) from the Valanginian part of the Spiti shales, to which form it may be related.

Bochianites Lory 1898

Bochianites paskentaensis Anderson, n. sp.

(Plate 29, figure 10)

Bochianites paskentaensis Anderson, Geol. Soc. Amer., Bull., vol. 44, 1933, p. 1259; "Zone M2," McCarthy Creek, Tehama County.

This unusual species is known from a number of fragments of a small, straight ammonoid shell found in the Paskenta group in its type district. In section it is subcircular or broadly elliptical. The shell itself is somewhat obliquely costate, although the cast is usually smooth. In form and sculpture the species is not unlike *Bochianites oosteri* Sarasin and Schondelmayer, having the same number of sutural elements of quite similar character. The holotype (Calif. Acad. Sci. type Coll.) was obtained from the Wilcox ranch, where it was associated with *"Simbirskites" mutabilis* Stanton, at the top of the *"Aucella crassicollis zone."* It has the following dimensions: length, 67 mm.; greatest diameter, 7 mm.; diameter at smaller end, 5 mm. The shell tapers very gradually, some of the examples showing a diameter of

only 1 mm. Like *Bochianites oosteri* it may represent the stratigraphic position of *Bochianites neocomiensis* (d'Orbigny). The species has also been found near the base of the Paskenta group, 2 miles northwest of Paskenta. Its range is throughout the lower two-thirds of the group in its type district.

All the examples thus far found have been associated with *Aucella crassa*, *Aucella inflata*, and *Aucella crassicollis*. Its horizon is thought to be lower and middle Valanginian.

PARAHOPLITIDAE Spath 1924

Parahoplitoides Spath

Parahoplitoides shoupi Anderson, n. sp.

(Plate 32, figure 2)

Shell large, discoidal, somewhat compressed, involute, with moderately broad umbilicus; sides flattened, closely costate, ribs broad, flexuous, arising at the whorl suture, non-tuberculate, although swollen on the umbilical border in young stages of growth, smooth in older stages, branching into pairs near the middle of the side, and all continuing across the periphery without interruption; ventral zone scarcely flattened; section of whorl semi-elliptical, narrowing toward the periphery; whorl thickest a little above the middle of the side; suture line not well exposed in the holotype, but showing a tendency to asymmetry in the ventral zone and on the sides; siphonal saddle unsymmetrical, the siphonal notch inclining to the right; in this respect the suture resembles that of *Acanthoplites remondi* (Gabb).

The holotype (Calif. Acad. Sci. type Coll.) was obtained from the Shoup zone on Bee Creek, immediately above the Argonaut zone on the Shoup ranch, 4 miles south of Ono, Shasta County. It has about 66 ribs and has the following dimensions: greatest diameter, 202 mm.; width of umbilicus, 62 mm.; height of whorl, 65 mm.; thickness of whorl, 50 mm. In form and ribbing this species closely resembles *Parahoplitoides weissi* (Neumayr and Uhlig), although differing from it in some sutural elements. The holotype was found with *Phylloceras onoense*, *Tropaeum percostatum*, and a few other species, a little above the Argonaut zone, and somewhat higher above the horizon of *Australiceras argus*, as found on Bee Creek. The holotype is septate throughout and, when complete, must have exceeded 12 inches in diameter.

Parahoplitoides seniloides Anderson, n. sp.

(Plate 32, figure 1)

Shell large, discoidal, somewhat compressed, involute; umbilicus relatively narrow, sides costate only in young stages, smooth in older stages; ribs flexuous when visible, tuberculate in young stages only; umbilicus bordered by abrupt walls, which are rounded above, the curve merging with the almost smooth sides; periphery rounded in holotype. The holotype (Calif. Acad. Sci. type Coll.) has the following measurements: greatest diameter, 241 mm. (9.5 inches); diameter of umbilicus, 57 mm.; height of whorl, 60 mm.; thickness of whorl, 60 mm.; umbilical ratio, 0.236:1. All examples of this genus so far found have occurred in the Argonaut zone, characterized chiefly by *Lytoceras argonautarum* and *Phylloceras onoense*.

This species closely resembles *Parahoplitoides laeviusculus* (von Koenen), in form and ornamentation although it may be somewhat thicker in section. The horizon is the same as that of *Parahoplitoides shoupi*.

Parahoplitoides cerrosensis Anderson, n. sp.

(Plate 33, figure 1)

The strongly costate shell of this species is rather large, discoidal, compressed, with a moderately broad umbilicus; about 54 peripheral costae, somewhat flattened,

broader than the rounded interspaces, divided, or in two ranks; primary ribs arising on the umbilical walls, sloping backward below the rounded umbilical border, sometimes dividing below the middle of the side, more often single, alternating with secondary ribs; all ribs cross the ventral zone without weakening. In its younger stages the shell of this species resembles *Parahoplites deshayesi*, as figured by Neumayr and Uhlig (1881, pl. 46), which according to Kilian represents *P. consobrinus* d'Orbigny. The suture line is very similar to that of *Parahoplitoides shoupi* nov., the siphonal saddle being unsymmetrically divided by a deep cleft, the left side being the larger and more developed.

The holotype (Calif. Acad. Sci. type Coll.) affords the following measurements: greatest diameter, 135 mm.; width of umbilicus, 47 mm.; height of whorl, 38 mm.; thickness of whorl, 58 mm.; umbilical ratio, 0.348:1.

This specimen was found near Roaring River, 5½ miles south of Ono, Shasta County, in the Argonaut zone near the middle of the Horsetown group. It is not uncommon in this horizon in the Cottonwood district, from its type locality north to Hulen Creek and south to the middle fork of the Cottonwood Creek. The species seems to have an analogue in "*Acanthoplites*" *laticostatus* Sinzow (1907, p. 482, pl. 5, figs. 9–13), from the Caucasus Mountains, from which it differs chiefly in its more rounded periphery, flattened sides, and slightly more sinuous ribs.

Parahoplites Anthula

Parahoplites stantoni Anderson, n. sp.

(Plate 33, figure 2; plate 36, figure 3)

Among the interesting hoplitid species found in the Horsetown group of the Cottonwood district are three species akin to *Parahoplites uhligi* Anthula. All are robust forms with a relatively large umbilical ratio. The present species is represented by only the holotype (Calif. Acad. Sci. type Coll.), found at Locality 1348 (Calif. Acad. Sci.), near the forks of Alderson Creek, 2 miles south of Ono, Shasta County.

This example is almost wholly septate and affords the following measurements: greatest diameter, 146 mm.; diameter of umbilicus, 51 mm.; height of whorl, 58 mm.; width of whorl, 45 mm.; umbilical ratio, 0.349:1.

In section the whorl is ellipsoidal, somewhat quadrate, the greatest thickness being below the middle of the side; surface strongly costate, with ribs of two ranks; 28 stronger primary ribs sinuous, arising on the umbilical wall, inclining at first backward to the umbilical border, then rising vertically to the middle of the side, there curving gently backward, then forward to the periphery; secondary ribs smaller, arising singly or in pairs near the middle of the side; on the periphery, about 75 ribs to the whorl; all ribs cross the ventral zone without interruption; ventral zone slightly flattened, rounded on the borders; umbilical walls abrupt, rounded above; sides flattened, or only slightly convex; septal sutures not fully shown, although the siphonal saddle and lobes show the lack of symmetry common to most of the California species of Parahoplitidae. The holotype has the general form and surface characters of *Parahoplites uhligi* Anthula, but a somewhat larger umbilical ratio, more sinuous ribs, and a thicker section. It was found with *Tropaeum percostatum*, *Parahoplitoides*, and other species in the middle part of the Horsetown group.

Parahoplites dallasi Anderson, n. sp.

(Plate 34, figures 1, 2)

A more extreme member of the same group was found in the lower part of the Shoup zone east of Mitchell Creek. It is considerably thicker and stouter, with

greater involution, a smaller umbilical ratio, and fewer and less sinuous ribs. In the several examples found the number of umbilical ribs varies from 24 to 28, and the peripheral ribs from 52 to 60 to the whorl.

The holotype (Calif. Acad. Sci. type Coll.) is entirely costate and has the following dimensions: greatest diameter, 135 mm.; diameter of umbilicus, 44 mm.; height of whorl, 62 mm.; width of whorl, 58 mm.; umbilical ratio, 0.430:1.

In cross-section the whorl is broadly semi-elliptical, the thickest part of the whorl being a little above the umbilical border; whorl heavily costate, the ribs being of two ranks; sometimes divided primary ribs are less sinuous than in the preceding species; almost twice as many peripheral ribs as those on the umbilical border; some of the primary ribs divide into two or three, some do not divide; all ribs cross the broad and slightly flattened ventral zone; umbilicus narrow and deep, with steep walls, smooth below, ribbed above.

This specimen was found not far from the horizon of *Tropaeum percostatum*, *Phylloceras onoense*, and *Parahoplitoides*, about 60 feet above the Argonaut zone. The specimen was found by G. D. Hanna, for whom it is named, at Locality 1347 (Calif. Acad. Sci.), half a mile east of Mitchell Creek, 5 miles south of Ono, Shasta County. An example of closely related species was found by O. W. Friedrich, about 7 miles northeast of Wilbur Springs, western Colusa County. The horizon of both is near the middle of the Horsetown group and marks a lower Gargasian level.

Parahoplites scharfi Anderson, n. sp.

(Plate 73, figures 4, 5)

The shell of this species is moderately robust, or inflated, and in form is intermediate between *Parahoplites dallasi* nov. and *P. stantoni* nov. It more nearly resembles *Parahoplites subcampechi* Sinzow (1907), from Mangyschlak, and may be regarded as its California analogue. The holotype possesses about 40 rather strong, slightly sinuous ribs, which arise on the umbilical wall, having a backward inclination, and show a slight swelling on the umbilical border, cross the sides with a slight forward slant, bending sharply forward in the ventral zone. Most ribs divide into two below the middle of the side, although there is an occasional single rib interpolated between the pairs resulting from division. The holotype has the following dimensions: greatest diameter (of complete whorl), 85 mm.; width of umbilicus, 25 mm.; height of whorl, 41 mm.; thickness of whorl, 35 mm.; umbilical ratio, 0.294:1.

The suture line is not well shown. This example was found at the "north end of the Bald Hills" by D. W. Scharf and W. P. Popenoe, Locality 968 (Calif. Inst. Tech.), for the first of whom it has been named. The species differs from its analogue at Mangyschlak in being somewhat more robust, in having stronger and fewer ribs, which show a slightly more pronounced curvature. The holotype is the property of the California Institute of Technology, Pasadena. Its horizon is but little above that of *Tropaeum percostatum* (Gabb) and beneath that of *Hemibaculites mirabilis* nov.; it therefore represents the middle part of the Aptian portion of the Horsetown group.

Parahoplites macfarlandi Anderson, n. sp.

(Plate 35, figure 1)

Shell large, robust, involute, with moderately broad umbilicus; section of whorl semi-elliptical in young stages, becoming sub-quadrate in older age; sides costate, with closely set, rounded, depressed ribs, which arise on the umbilical wall with a backward slant, curving gently forward above; umbilical walls abrupt, rounded

above, border bearing somewhat thickened umbilical ribs; septa as shown in the figure; ribs often dividing.

The holotype (Calif. Acad. Sci. type Coll.) was found by Andrew McFarland on Alderson Creek, about 2 miles south of Ono, Shasta County. It has the following dimensions: greater diameter, 209.5 mm.; width of umbilicus, 58 mm.; ratio, .277:1, height of whorl, 90 mm.; ratio, .429:1; width of whorl, 75 mm.; ratio, .362:1.

According to accounts given by the discoverer the holotype was found at a horizon somewhat above the Argonaut zone in beds referable to an upper Aptian stage. No more exact statement of its occurrence can now be given.

Acanthoplites Sinzow

Among the large number of parahoplitid forms described by Anthula (1900, p. 102–119), from the Caucasus Mountains, Sinzow (1907, p. 478–506) has distinguished a group for which he has established the genus *Acanthoplites*. In this group the whorls are more compressed, the umbilicus broader, and the venter more rounded than *Parahoplites* Anthula, wherein it seems to retain characters of *Parahoplitoides* Spath. The genotype of this group is "*Parahoplites*" *aschiltaensis* (Anthula). Under the genus *Acanthoplites* Sinzow has figured and described as many as 15 different forms which he regards as distinct species. Many of these forms in their young stages possess characters of *Acanthoceras* or of *Douvilleiceras*, such as spines, or tubercules on the umbilical borders or at the point of division of the ribs. These features are usually lost in the older stages of growth, and in some cases new features are acquired, as happens in other groups.

In the middle and upper parts of the Horsetown group (upper Aptian to middle Albian) similar forms are abundant and include many species that may be regarded as analogues of those found in the Caucasus regions. Some of these will be noted as such in the descriptions, although materials are not yet at hand for a complete account of all of them. In their younger stages some of them approach, or perhaps retain, characters of *Parahoplites* or even young examples of *Parahoplitoides*, on the one hand, and on the other have the spinose ornamentation of *Cheloniceras* or *Douvilleiceras* and without the mature shells they may easily be mistaken for such. In fact, in the past, some have been referred to *Acanthoceras* and *Douvilleiceras*.

Acanthoplites aegis Anderson, n. sp.

(Plate 30, figure 1)

Shell large, discoidal, moderately involute, umbilicus moderately broad, sides closely costate, about 64 ribs on the last whorl of the holotype; ribs rounded, slightly sinuous, sometimes single, more often divided, crossing the periphery without weakening or flattening; umbilicus bordered by low, abrupt walls, upon which arise the primary ribs; periphery rounded. This species resembles *Parahoplites stantoni* nov. but it is readily distinguished by its broader umbilicus, relatively thinner section, and its fewer and broader ribs. The holotype (Calif. Acad. Sci. type Coll.) affords the following measurements: greatest diameter, 235 mm.; width of umbilicus, 95 mm.; height of whorl, 85 mm.; thickness of whorl, 56 mm.; umbilical ratio, 0.404:1. The holotype was found by Andrew McFarland on Alderson Creek, 2 miles south of Ono, Shasta County. It represents the upper middle Horsetown group, locality 1348 (Calif. Acad. Sci.). Its sutural characters are not unlike those of *Parahoplites*. This is not the largest representative of the genus found, but in diameter it approaches the largest. Smaller examples of the species have been found higher in the section, near the top of the Cottonwood beds, or at the base of the Hulen beds, on the Hulen Creek drainage.

Acanthoplites remondi (Gabb)

(Plate 39, figure 1)

Amm. Remondii GABB, Paleont. Calif., vol. 1, 1864, p. 66, pl. 12, figs. 14, 14a, (not fig. 15); North fork of Cottonwood Creek, Shasta County, California.

The holotype of this species is in the Museum of Paleontology, University of California (type 162), and has been carefully studied and compared with many individuals representing this and closely related species. In form, especially in its lateral aspect, the holotype greatly resembles *"Parahoplites" consobrinus* (d'Orbigny), but it is thicker in section and has a distinctly different suture line, as shown in the figure. The holotype, No. 162 (Univ. Calif. Coll.), septate throughout, has the following dimensions: greatest diameter, 137 mm.; width of umbilicus, 57 mm.; height of whorl, 48 mm.; thickness of whorl, 37 mm.

This example possesses 38 thickened, rounded, and somewhat sinuous primary and secondary ribs, which occur alternately.

This holotype represents a small group of nearly related forms from the upper part of the Horsetown group in the Cottonwood district. In this group the whorl section is comparatively thick, the ribs strong and often elevated, and the umbilicus occupies about one-third the diameter of the whorl. The nearest foreign analogue of this species known at present is probably *Acanthoplites abichi* (Anthula), from the Caucasus Mountains, as figured by Sinzow (1907, pl. 7, figs. 1–3).

The exact horizon of *Acanthoplites remondi* is not yet known, although it clearly belongs to the middle or upper part of the Horsetown group (upper Aptian).

Hyatt referred this species to *Acanthoceras*, but upon what basis is not now clear. A noticeable feature of the suture line is its deeply cleft siphonal saddle and its asymmetry, the divisions on the right side being smaller and less developed. This lack of symmetry runs through the family and extends to other elements of the suture line, but to what extent is not yet fully known. In some species the left side shows the less developed sutures, but whether these are individual or accidental features is not yet known. Suture lines representing a few of the species will be given.

Acanthoplites gardneri Anderson, n. sp.

(Plate 37, figure 1; plate 54, figure 1)

Shell large, moderately robust, with rather broad umbilicus and numerous well-developed ribs, the holotype possessing 56 to the whorl; involution nearly one-third; transverse section somewhat elliptical, as shown in the figure; ribs of two ranks, alternately primary and secondary; primary ribs arise on the abrupt umbilical walls in stout ridges sloping backward up to the rounded umbilical border, from which they pass upward in a slightly sigmoid curve to the ventral zone, which they cross without interruption or diminution; a few of the primary ribs bifurcate a little below the middle of the side; secondary ribs arise near the middle of the side and cross the ventral zone as do the others.

In transverse section the shell is somewhat compressed, the sides being flattened near the middle; it thus differs from the convex form of the preceding species; the ribs are also narrower and more numerous than in *Acanthoplites remondi*, but are rounded in form and are apparently without tubercules at any stage. The suture line is not unlike that of *A. remondi*, having the siphonal saddle deeply cleft by an oblique incision, from which an asymmetry of the line begins, the right side being the less developed. Whether this asymmetry results from habitual position on the sea floor is not known.

The holotype (Calif. Acad. Sci. type Coll.) has the following dimensions: greatest

diameter, 220 mm.; diameter of umbilicus, 78 mm.; height of whorl, 85.5 mm.; width of whorl, 69 mm.; umbilical ratio, 0.355:1.

The holotype was obtained from the North fork of Cottonwood Creek, probably above the Argonaut zone, by J. W. Gardner. It is now in the collections of the California Academy of Sciences.

Acanthoplites perrini Anderson, n. sp.

(Plate 38, figure 1)

Shell large, thickly discoidal, latumbilicate, rounded on the periphery, heavily costate; umbilicus broad, with abrupt walls, rounded on the borders; having slightly curved, rounded primary and secondary ribs; primary ribs mostly simple, occasionally branching, arising on the umbilical wall as a backward sloping ridge, curving on the umbilical border and rising nearly at right angles across the side to the ventral zone; nearly twice as many secondary ribs as primary, arising at or above the middle of the side; all ribs cross the ventral zone without interruption; suture line, as shown in the figure, has a deeply cleft siphonal saddle, showing asymmetry with reference to the siphonal plane, and asymmetry in the successive divisions of the lobes.

The holotype (Calif. Acad. Sci. type Coll.), almost wholly septate, affords the following measurements: greatest diameter, 230 mm.; diameter of umbilicus, 90 mm.; height of whorl, 90 mm.; width of whorl, 65 mm.; umbilical ratio, 0.39:1.

This specimen was obtained in the Perrin zone on the west branch of the east fork of Hulen Creek, east of Ono, at Locality 145 (Calif. Acad. Sci.). It was associated with *Cheloniceras* sp., *Cleoniceras* cf. *lecontei*, *Nautilus gabbi*, and other species. Its position is above that of the Buenaventura zone of the Hulen beds referable to a lower middle Albian horizon.

This species seems to have its nearest analogue in *Acanthoplites nolani* (Seunes), as illustrated by Sinzow (1907, pl. 8, fig. 1) from the Caucasus Mountains. The species is named in honor of the late James Perrin Smith, for many years Professor of Paleontology at Stanford University.

Acanthoplites spathi Anderson, n. sp.

(Plate 41, figures 3-5)

Like the preceding forms, this shell is of moderate size, discoidal, inflated, with moderately broad umbilicus; section of whorl subcircular, rounded on sides and periphery; walls of umbilicus sloping, rounded above, blending with the sides; 32 to 38 elevated primary and secondary ribs; primary ribs arising on the umbilical wall, rectiradiate, often branching in younger stages of growth, and bearing short spine-like processes at the points of division; secondary ribs, in older stages of growth, arising near or above the middle of the side; shell in younger stages having the aspect of *Cheloniceras*; interspaces between ribs deep, as broad as the ribs themselves. The holotype (Calif. Acad. Sci. type Coll.) affords the following measurements: greatest diameter, 70 mm.; width of umbilicus, 26 mm.; height of whorl, 25 mm.; thickness of whorl, 25 mm.; umbilical ratio, 0.371:1. In older stages the branching of the ribs and the spines become obsolete and are finally lost, the ventral zone becomes flattened, and the ribs become more prominent on the periphery. The species appears to belong to a group represented by *Acanthoplites abichi* (Anthula) as figured by Sinzow (1907, pl. 6, figs. 1-3). The holotype and the other figured examples were found at Locality 1346-A (Calif. Acad. Sci.), on the west branch of Hulen Creek, in the Buenaventura zone, or just beneath it, in the upper part of the Horsetown group. It has been found also on Alderson Creek and on Bee Creek, presumably in the same zone. Its horizon is near the top of the Aptian portion of the Horsetown group.

Acanthoplites barryana Anderson, n. sp.

(Plate 48, figures 1, 1a)

Shell of moderate size, sharply costate, latumbilicate; walls of umbilicus abrupt below, rounded above; sides of shell flatly convex, periphery rounded; about 28 sharp, elevated ribs, mostly of one order, occasionally branching a little below the ventral border; interspaces broadly concave; ribs straight, apparently weakly spinose in young stages.

The holotype (Calif. Acad. Sci. type Coll.) affords the following measurements: greatest diameter, 110 mm.; diameter of umbilicus, 44 mm.; height of whorl, 40 mm.; width of whorl, 30 mm.; umbilical ratio, 0.4:1.

The holotype was found on Hulen Creek, in the upper part of the Horsetown group, and seems probably to represent the Perrin zone of the Hulen beds. The species appears to belong to the group represented by *Acanthoplites bigoureti* (Seunes) as interpreted and figured by Sinzow (1907, pl. 6, figs. 4–6) from the Caucasus Mountains, southwest Asia.

Acanthoplites sub-bigoti Anderson, n. sp.

(Plate 76, figure 2)

Shell small, discoidal, somewhat inflated, with roundly elliptical section of whorls, about 52 generally prominent ribs, with sharp edges and with interspaces broader than the ribs; ribs arising on the umbilical wall, with a backward slant, crossing the side in almost a straight line, or with a slight forward curve on the sides and on the periphery; ventral zone slightly flattened on the larger whorl, shell bearing reduced spines at the middle of the sides on the younger whorls. The holotype has the following dimensions: greatest diameter, 40 mm.; width of umbilicus, 15 mm.; height of whorl, 16.5 mm.; thickness of whorl, 13 mm.

The species shows a close resemblance to *Acanthoplites bigoti* Seunes, from the Caucasus Mountains, as figured by Sinzow (1907, pl. 4, figs. 18–20), of which it is a near analogue. This example was found at Locality 965 (Calif. Inst. Tech.), in beds of middle Aptian age on the Cottonwood Creek, near Ono, Shasta County, where it was associated with *Douvilleiceras mammillatum*, var. The holotype is the property of the California Institute of Technology, and was found by W. P. Popence and D. W. Scharf.

DOUVILLEICERATIDAE Spath, 1921

Douvilleiceras Grossouvre

Genotype *Ammonites mammillatus* Schlotheim

Douvilleiceras aff. *mammillatum* (Schlotheim)

(Plate 36, figure 3)

Acanthoceras cf. *mammillare* STANTON, Geol. Soc. Amer., Bull., vol. 5, 1894, p. 445; upper Horsetown beds, Shasta County, California.

Douvilleiceras mammillare ANDERSON (in part), Calif. Acad. Sci., Pr., 3d ser., vol. 2, 1902, p. 108; Hulen Creek, Shasta County.

Spath (1921–1922a, p. 68–73) has given much critical information concerning the English and French species referable to this generic group. This information aids in the study of the relationships of the California forms found in the Albian strata of the Cottonwood district. Of these there is a good number of examples available, not all of which seem referable to a single species. Some of these examples come within the range of variation indicated by Spath, others do not.

In the Museum of Paleontology, University of California, there are a number of specimens representing types found in France, and in the California Academy of Sciences are others from western Europe. In an earlier study of these forms and their analogues from California their close relationship was indicated by Anderson, (1902a, p. 108), although the conclusion was reached that many of the surface characters in the California examples, as well as those from France, were not constant.

In addition to the remarks formerly given concerning the forms found in the Cottonwood district, Shasta County, the following notes may be of value.

The most common form in the upper Horsetown beds in the Cottonwood district seems to extend through a considerable stratigraphic range, appearing first in the Buenaventura zone, but also at higher levels, up to the Neptune zone, and thus being found through at least 1350 feet of strata. A typical example from the Perrin zone (Locality 1668, Calif. Acad. Sci.) affords the following measurements: greatest diameter, 84 mm.; width of umbilicus, 30 mm.; height of whorl, 30 mm.; width of whorl, 40 mm.; umbilical ratio, 0.357:1.

In this example, the last whorl is two-thirds septate and includes about 22 ribs; the most spinose ribs (diameter 72 mm.) show seven nearly conical tubercules, of which the bases are slightly elongated in the direction of the rib, although this is not constant; in earlier ribs the direction of elongation is transverse to that of the ribs; in younger whorls the tubercules of the second row above the umbilical border are more spine-like, some of the spines rising 2 mm. above their bases. An example from the Buenaventura zone, west branch of Hulen Creek, shows the same form of whorl, the same number and character of ribs, with the same broad interspaces, and spines of the same kind, yet the interval between the two horizons is hardly less than 700 feet.

In most examples the ribs are narrower and the interspaces broader than in the examples illustrated by Spath.

Douvilleiceras aurarium Anderson, n. sp.

(Plate 53, figure 1)

A single example of a species of *Douvilleiceras* related to the preceding was found in the Bradley zone on the east branch of Hulen Creek. This example has been carefully compared with others of the genus, but it shows specific differences from all of its congeners. It possesses an umbilicus relatively broader than any of the others, and, although the number of ribs is nearly the same as in *Douvilleiceras mammillatum*, the tubercules are less numerous, more rounded, and on the ventral borders they are not always multiple and do not appear to be spinose. The holotype (Calif. Acad. Sci. type Coll.) has the following dimensions: greatest diameter, 85 mm.; width of umbilicus, 35 mm.; height of whorl, 30 mm.; thickness of whorl, 40 mm.; umbilical ratio, 0.412:1. In its younger stages, the costal tubercules appear in three rows, in which their size varies greatly. The sulcate ventral zone is rather narrow and has a zone of mostly multiple tubercules bordering it on either side; a second row consisting of single rounded tubercules appears near the middle of the side; even in its younger stages these rise in rather blunt points, scarcely to be called spines; a third row, much reduced in size, is developed on the umbilical border, but only in young stages of growth. In its more mature stages all the costal tubercules tend to become obsolete.

Douvilleiceras restitutum Anderson, n. sp.

(Plate 54, figure 2)

Ammonites Remondii Gabb (in part), Palcont. Calif., vol. 1, 1864, p. 66, pl. 12, fig. 15, only; "nodose variety" (not pl. 12, figs. 14, 14a); Cottonwood Creek, Shasta County.

In Gabb's (1864, p. 66, pl. 12, fig. 15) description of *Acanthoplites remondi* (Gabb) he referred to a "second form," which he also figured. His specimen has not been found, although it may later be discovered among the collections in the Museum of Paleontology, University of California.

An example now in the Museum of Paleontology was obtained by the writer in 1897 at the old mining camp of Horsetown, Shasta County. This specimen seems to fulfill the essentials of Gabb's figure and description. It is made the holotype of the above species. In this example the shell is large, discoidal, with moderately broad umbilicus, strongly costate; with 34 ribs on the adult whorl, 56 on last whorl; umbilicus deep, walls abrupt, rounded or subangular on the border; ribs arising on the umbilical wall, at first sloping backward, then rectiradiate, tuberculate on younger whorls only; ribs non-tuberculate above a diameter of 90 mm.; below this diameter the ribs bear three to five rounded, spinose tubercules, not quite evenly spaced; tubercules near the periphery stronger than below; umbilical nodes weaker in young whorls, becoming more developed in older stages; body-chamber occupying two-thirds of the last whorl upon which the umbilical bullae are well developed, giving rise to two or three slightly sinuous ribs which cross the rounded ventral zone without interruption.

On the holotype the greatest diameter is 153 mm.; diameter of umbilicus, 46 mm.; height of whorl, 65 mm.; width of whorl, 75 mm.; umbilical ratio, 0.301:1.

According to Gabb's statement his figure represents the inner whorls of a much larger shell, measuring 15 inches in diameter.

CHELONICERATIDAE Spath 1921

Spath has included in this family a number of related genera, of which only the following two have been found in the Lower Cretaceous of California:

Prochelonicerас Spath; genotype, *Ammonites stobieckii* (d'Orbigny) and

Cheloniceras Hyatt 1896; genotype *Ammonites royerianus* (d'Orbigny).

Both of these generic groups have been found in the upper part of the Shasta series, the first in beds near the base of the Horsetown group (upper Barremian) and the second near the base of the Hulen beds in strata that seem referable to the lower Albian.

Cheloniceras Hyatt 1903

Cheloniceras stoliczkanum (Gabb)

(Plate 47, figure 3)

Ammonites Stoliczkanus GABB, Paleont. Calif., vol. 2, 1869, p. 135, pl. 23, figs. 16, 16a; "Shasta Group," Cottonwood Creek, Shasta County, California.

Acanthoceras stoliczkanum UHLIG, Wernsdorfer beds, 1883, p. 254.

Douvilleiceras stoliczkanum DOUVILLÉ; Valley of the Amazon, Ann. Soc. Zool. Malac. Belg., T. 41, 1906, p. 145, pl. 1, fig. 1.

Cheloniceras stoliczkanum BASSE, Soc. Geol. France, Bull. T. 28, 1928, p. 141, pl. 8, fig. 2; Middle Cretaceous, Republic of Colombia.

The characterization of this species by Gabb seems to need no special comment. Nevertheless, in view of its exceptional occurrences and interest, some additional notes may be helpful in determining its geographic range.

The holotype of the species is in the Museum of the Academy of Natural Sciences of Philadelphia. Gabb's drawing seems to have included a partial restoration, but otherwise is excellent. The 29 ribs are of two kinds, major and minor, alternating on parts of the shell only. The major ribs bear three rows of tubercules, elongated in the direction of the ribs, one row being on the umbilical border, one on the ventral

border, and one near the middle of the side; the minor ribs have only the two latter rows, and some of them show scarcely any tubercules, or only swellings.

The holotype affords the following measurements, differing somewhat from Gabb's: greatest diameter, 90 mm.; diameter of umbilicus, 30 mm.; height of whorl, 38 mm.; width of whorl, 48 mm.; umbilical ratio, 0.333:1.

The exact horizon from which the holotype was obtained is not definitely known, although an immature shell that seems to belong to the species was found on Hulen Creek in the Bradley zone, which also contains *Cheloniceras bradleyi* and another related species. It seems probable that this is the zone from which Gabb's holotype came. This zone is situated about 340 feet above the Buenaventura zone of the Hulen beds and nearly 1700 feet below the top of the Horsetown group. Its position on the chronologic scale of Europe is probably lower Albian. Gabb has compared it to European species from the Gault. The species does not appear to have been found at any other place or horizon in California. Whiteaves seems to have figured more than one form under this name, all of which he later included under the name *Acanthoceras spiniferum* ("Nom. mut."). Kossmat, to whom a specimen of "*Acanthoceras spiniferum*" Whiteaves was sent, seems to have regarded it as belonging to *Douvilleiceras*, rather than any type here included in *Cheloniceras* Hyatt. None of the forms figured by Whiteaves appear to belong to Gabb's species.

Cheloniceras bradleyi Anderson, n. sp.

(Plate 52, figures 1, 2)

Shell large, robust, very broad, with deep umbilicus; few whorls, bearing about 20 major ribs with intervening smaller ribs that occur in pairs on the large whorls; major ribs tuberculate, with three rows of rounded but elongated, although not prominent, nodes; one pair on the ventro-lateral zones, bearing transversely elongated "bullae," an inconspicuous one on the umbilical border, and a rather prominent one on the middle of the side; smaller intervening costae without nodes; umbilicus deep, walls smooth and vertical, or showing faint backward-sloping grooves; ribs crossing the periphery; periphery excavated on major ribs only, rounded between.

The holotype (Calif. Acad. Sci. type Coll.) has the following dimensions: greatest diameter, 155 mm.; width of umbilicus, 55 mm.; height of whorl, 58 mm.; width of whorl, 85 mm.; umbilical ratio, 0.355:1.

Two incomplete examples of this species were obtained at Locality 159 (Calif. Acad. Sci.) near the head of the east fork of Hulen Creek, about 340 feet above the Buenaventura zone of the Hulen beds. Its horizon is near the lower limit of the Albian or possibly in the highest beds of the Aptian division of the Horsetown group.

This species differs from *Cheloniceras stoliczkanum* (Gabb) in being much more robust and broader, with less prominent ribs, and tubercules. It appears to belong in nearly the same zone, as determined by the strike of the beds and the stratigraphic relations. The zone of this species is here known as the Bradley zone. Two young and immature examples of *C. stoliczkanum* were obtained at Locality 159 (Calif. Acad. Sci.) associated with the present species.

Cheloniceras populorum n. sp.

(Plate 53, figure 2)

A single large but incomplete example of a species of *Cheloniceras* nearly related to *C. bradleyi* was found associated with it on the head of the east branch of Hulen Creek (Locality 156, Calif. Acad. Sci.), and a similar example of the same was found

on the North Fork of Cottonwood Creek, 1½ miles above the mouth of Hulen Creek, in the same zone, associated with *Acanthoplites* sp. and *Turnus planus* Gabb.

In this specimen the major ribs occur in pairs, and on the latter half of the body whorl there are about eight such pairs, some of which unite in a broad bulbous tubercule on the umbilical border, others unite in a similar tubercule a little below the middle of the side; secondary ribs occur between these pairs arising on the lower part of the whorl above the umbilical border, not tuberculate except on the ventrolateral zone; in younger whorls some of the major ribs bear prominent bulbose tubercules upon the border of the ventral zone. In form and general dimensions this species is not unlike *Cheloniceras bradleyi* and occurs in the same zone.

Cheloniceras irregulare Anderson, n. sp.

(Plate 46, figures 2–4)

Shell of medium size, discoidal, little compressed, with moderately broad umbilicus; few ribs, nearly all of one order, uniformly broad, separated by interspaces a little broader than the ribs; in younger stages the ribs are furnished with three rows of low, spinose tubercules, which are lost at a diameter of 50 mm., becoming first rounded, and then obscure except on the ventral borders where they become more strongly developed; ribs and interspaces crossing the periphery; ribs much depressed in the ventral zone, forming a broad saddle between the elevated tubercules on the ventral borders; tubercules elongated parallel to the siphonal plane, prominent only in adult stages, becoming lost in older stages, in which the ribs cross the ventral area as prominent ridges without tubercules. The holotype (Calif. Acad. Sci. type Coll.) has the following dimensions: greatest diameter, 110 mm.; width of umbilicus, 35 mm.; height of whorl, 35 mm.; thickness of whorl, 33 mm.; umbilical ratio, 0.318:1.

In form and ornamentation this species recalls "*Acanthoceras*" *confusum* Gueranger, from the Cenomanian beds near Hanover, Germany, although near relationship is not claimed. In general features the form also bears some resemblance to *Ammonites michelinianus* d'Orbigny, referred to by Gabb (1869a, p. 130) in his description of *Cheloniceras stoliczkanum*. The holotype of the present species was found about 400 feet beneath the Buenaventura zone on the west branch of Hulen Creek, 1½ miles above its entrance into Cottonwood Creek. The shell of this unusual form possesses characters of *Cheloniceras*, but has no spines in its youngest and oldest stages, whereas in its intermediate stages it develops a succession of changing types of spines. Its horizon is believed to be near the boundary of Aptian and Albian stages, in the upper part of the Horsetown group. Only a single specimen has yet been found referable to this species.

Cheloniceras recsidei Anderson, n. sp.

(Plate 47, figure 1)

Shell moderate in size, discoidal, little compressed, broadly umbilicate; section of whorl subelliptical, a little inflated, rounded on the sides and on the umbilical border, flattened or slightly concave on the periphery in young adult stages of growth; sides costate, having primary and secondary ribs; primary ribs bearing three narrow, little prominent tubercules, seen mostly on younger whorls; ribs becoming smoother and narrowly ridge-like at maturity, separated by wide interspaces; secondary ribs arise on the umbilical border as fine intermediary costae, becoming stronger near the ventral border, without tubercules; all ribs cross the ventral area, slightly tuberculate on its borders, but sag a little near the siphonal line. The holotype (Calif. Acad. Sci. type Coll.) has the following dimensions:

greatest diameter, 91 mm.; width of umbilicus, 42 mm.; height of whorl, 28 mm.; thickness of whorl, 25 mm.; umbilical ratio, 0.461:1. This species greatly resembles *Acanthoplites multispinatus* (Anthula), as figured (Anthula, 1900, p. 119, pl. 10) by this author. There is less resemblance seen in the figures given by Sinzow (1907, pl. 7, figs. 1–6), except in the younger stages. Three examples of this species were obtained a little beneath the Buenaventura zone, on the west branch of Hulen Creek, where it seems to be somewhat abundant. In its younger whorls this species exhibits at their best the spinose features of *Cheloniceras*, which are largely lost in the more mature stages, as is the case in other species of this genus.

Cheloniceras (*Prochelonicerας*) *hindsi* Anderson, n. sp.

(Plate 51, figures 1–3)

Shell of medium size, inflated, broadly umbilicate, strongly costate, section of whorl subcircular, broader than high; umbilical walls steep, rounded above, curving regularly to the rounded sides; about 40 ribs in two ranks, the stronger arising on the umbilical wall, often bifurcating from elongated nodes on the umbilical border; the alternate weaker ribs arise on the side near the umbilical border without nodes; all ribs cross the ventral zone without interruption, but with a slight flattening. In younger stages of growth the major ribs bear two additional nodes, one near the middle of the side, from which the ribs sometimes divide; the other and weaker node on the ventral border produces there a wide angle, and in young stages a flattening of the ventral zone. This shell, although having fewer ribs, bears much resemblance to *Douvilleiceras seminodosum* (Sinzow) from the lower Aptian of France, as figured by Kilian (1910, pl. 9, fig. 1). The holotype (Calif. Acad. Sci. type Coll.) was found by N. E. A. Hinds on Fiddler Creek, a mile above its mouth, 10 miles south of Ono, Shasta County, in beds containing *Acroteuthis shastensis*, *Acroteuthis impressa*, and other species a little above the horizon of *Shasticrioceras poniente* nov. The holotype has the following dimensions: greatest diameter, 80 mm.; width of umbilicus, 34 mm.; height of whorl, 30 mm.; width of whorl, 40 mm.; umbilical ratio, 0.425:1. Three other less complete examples of the same species were obtained at the same locality. The horizon is regarded as upper Barremian.

Cheloniceras fenoyi Anderson, n. sp.

(Plate 26, figure 3; plate 28, figure 8)

Shell rather large, inflated, broadly umbilicate, heavily ribbed, the ribs separated by interspaces somewhat broader than the ribs themselves; ribs often double, crossing the periphery without interruption or diminution; section of whorl broader than high, slightly coronate. The holotype (Calif. Acad. Sci. type Coll.) consists of a large fragment having the following dimensions: length, 98 mm.; height of whorl, 45 mm.; width of whorl, 50 mm.; width of umbilicus (est.), 50 mm. This holotype was found in "Zone U" in the lower part of the Horsetown group on McCarthy Creek, near the Lowry-Paskenta road, associated with *Terebratula hannana*. In general characters it is not unlike *C.* (*Prochelonicerας*) *hindsi* nov. from near the same horizon on Fiddler Creek, in the Cottonwood district, Shasta County. It is, however, relatively broader, as compared to its diameter, and is more coarsely ribbed, and apparently larger.

DESMOCERATIDAE Zittel, emend. Spath, 1921

Although this family forms an important element in the fauna of the Lower Cretaceous of California, insofar as definitely known, it is confined almost entirely to the Horsetown group. There are records of the occurrence of members of the family

in almost the earliest beds of the Paskenta group, but at best they are rare, and the family does not attain prominence until the latter part of Horsetown time (early-middle Albian). From this time on, they appear in increasing numbers up to the close of Horsetown time (late Albian) and they are plentiful in the lower beds of the Chico series (late Albian and Cenomanian time). It is not supposed that the several generic groups in this family have had local origin, although there are reasons for believing that most of them belong in a common lineage. Moreover, there appears to be sequential order in their appearance in the Great Valley embayments, and it may be possible to find there antecedents for some of them.

Without attempting at this time a discussion as to their origin and development, we may at least indicate here a number of generic groups and their stratigraphical sequence, as follows:

Melchiorites Spath first appears in upper-middle Horsetown (mid-Aptian) time, and continues only to the base of the Hulen beds (lower Albian time).

Desmoceras Zittel (group of *D. voyi*), found only in upper Aptian horizons.

Puzosia Bayle, found in upper beds of the Horsetown group (upper Aptian to upper Albian time), continuing into the Chico series (Cenomanian time).

Desmoceras (*Latidorsella*) (group of *D. merriami*), appearing first in the Perrin zone with *Douvilleiceras mammillatum* var. (middle Albian time), but having its best development in the Neptune zone (upper-middle Albian time).

Beudanticeras Hitzel is found first in the Neptune zone, with the preceding, and continues into the Chico series (uppermost Albian time).

It may be added that *Puzosia* (group of *P. planulata*) is found with *Oxytropidoceras packardi* nov. in the upper part of the Horsetown group (upper Albian); *Desmoceras* (group of *D. jugale* and *D. alamoense* nov.) also appears in the lower beds of the Chico series with *Pervinquieria inflata* var. These forms are followed in the Chico series by various others that are referable to either *Desmoceras*, *Puzosia*, or later to *Hauericeras*, but these will be considered at a later time.

Spath has proposed for certain Valanginian members of this family the generic name *Eodesmoceras*, but no forms referable to this group have yet been recognized in the California Cretaceous, or perhaps on the Pacific Coast.

It may be noted in passing that in their stratigraphic order all the recognized genera of Desmoceratidae are preceded by the earlier groups of Parahoplitidae—namely, by *Parahoplitoides* Spath, and, except for *Melchiorites* of the Aptian, by several species of *Parahoplites*. Spath has supposed, however, that the family Desmoceratidae includes a heterogeneous assemblage of types having origin in Phylloceratidae or in part in Lytoceratidae, both of which abound in the lower beds of the Shasta series (Paskenta group).

Desmoceras voyi Anderson

(Plate 40, figures 4-7)

Desmoceras voyi ANDERSON, Calif. Acad. Sci., Pr., 3d ser., vol. 2, 1902, p. 100, pl. 3, figs. 89, 90; North fork of Cottonwood Creek, Shasta County.

Shell rather small, discoidal or slightly inflated; umbilicus deep and narrow; ventral surface rounded, sides sloping gradually to the ventral border; marked by numerous fine flexuous growth lines and about six flexuous transverse grooves, seen more often on the cast; grooves bordered by a slight ridge on the shell; ridges more prominent on the periphery, here bending strongly forward, forming a sinus; section of whorl semi-elliptical in specimens of 50 mm. diameter, whereas it is more nearly circular in younger shells. The involution is deep, the outer whorl embracing more than three-fourths of the preceding whorl. The suture line is Desmoceratid, similar

to that shown by d'Orbigny for *Ammonites latidorsatus*, to which this species seems closely related. According to Kilian and Reboul (1901–1908, p. 25), this form should be referred to *Kossmaticeras* (group of *Madrasites bhavani* (Stoliczka)), but the basis for this view is not clear and needs confirmation. They have included under *Kossmaticeras* various ammonite forms from widely separated horizons in California and British Columbian sections, ranging from Jurassic to Senonian, although most of the species described as such from Seymour Island and Snow Hill seem to be Senonian in age. *Desmoceras voyi* somewhat resembles *D. dawsoni* Whiteaves, with which Yabe has compared it, although regarding them as distinct. *D. voyi* occurs in the Argonaut zone (middle Horsetown) where it is associated with *Lytoceras batesi* (Trask) and *Melchiorites shastensis* nov. in a middle Aptian horizon of the Cottonwood district, Shasta County. The holotype of *D. voyi* Anderson is in the Museum of Paleontology, University of California, and was found by the writer on the North fork of Cottonwood Creek, near Ono, Shasta County. Other examples have since been found in or near the Argonaut zone. It has the following dimensions: greatest diameter, 53.3 mm.; width of umbilicus, 8.4 mm.; height of whorl, 31.6 mm.; thickness of whorl, 28 mm.; umbilical ratio, 0.157:1. Specimens from the southeastern part of Graham Island, 2 miles north of the Indian village of Skidegate, which are indistinguishable from the California types, are in the collections of the California Academy of Sciences. They occur there associated with *Lytoceras argonautarum* Anderson, and with *Aucella indigenalis* nov., and other Aptian species. An example of *Desmoceras voyi* from this place, with an example of *Aucella* adhering to it, is figured on Plate 40 (figs. 6, 7, 8, and 8a). *D. voyi* was erroneously referred by Kilian and Reboul (1909, p. 25) to the upper Gault of the California section, although as stated in the original description its stratigraphical position is much lower. It is the oldest species of *Desmoceras* (s. s.) yet recorded from the Lower Cretaceous of the West Coast.

Desmoceras (*Latidorsella*) *merriami* (Anderson)

(Plate 43, figures 1, 2)

Ammonites Hoffmanni GABB (in part), Paleont. Calif., vol. 2, 1869, p. 131, pl. 20, figs. 8, 8a; Cottonwood Creek, Shasta County.
Pachydiscus merriami ANDERSON, Calif. Acad. Sci., Pr., 3d ser., vol. 2, 1902, p. 103, pl. 6, figs. 135–138; Hulen Creek, Shasta County, California.

The holotype of this species is in the Museum of Paleontology, University of California, and ten or more examples of it from the locality of the type are in the collections of the California Academy of Sciences, including the figured specimens.

The specimen figured by Gabb as the thicker form of *Ammonites hoffmanni* is in the collections of the Academy of Natural Sciences of Philadelphia and was loaned for examination and comparison. It is a good example of *D. merriami*[1] and, according to Gabb's notation, appears to have come from the Neptune zone on the North fork of Cottonwood Creek. This example was made the genotype of Hyatt's proposed genus "*Pleuropachydiscus*," which, if it has validity at all, should be regarded as a subgenus of *Desmoceras* Zittel and by priority should replace "*Latidorsella*" Ch. Jacob. The holotype of *Desmoceras merriami* (Anderson) has the following dimensions: greatest diameter, 97 mm.; width of umbilicus, 17 mm.; height of whorl, 51 mm.; width of whorl, 47 mm.; umbilical ratio, 0.175:1. It is septate throughout, and is the inner whorl of a much larger example. Fragments have been found that

[1] By some mischance, not due to the author, a page of the original manuscript (1902), intended for a following species,—*Pachydiscus henleyensis*,—was included in the description of *D. merriami*, to which other errors were added in comparing the species with "*Pachydiscus*" *suciensis* (Gabb), not Meek.

indicate a diameter of 10 inches. The shell is robust, little compressed, rounded on the abdomen, has a small umbilicus, of which the walls are abrupt below and rounded on the border; surface marked by about eight transverse, shallow, somewhat sigmoidal grooves, seen only on the cast, bordered in front by rounded ridges on the shell, more prominent on the abdominal area. The suture line of the species, not shown on Hyatt's "holotype," is clearly that of *Desmoceras*, resembling very closely, as far as it can be traced on the holotype of *D. merriami* and, on topotypes of the same, the figure of *Ammonites latidorsatus* given by d'Orbigny, although not showing the same number of auxiliary elements at its dorsal end. This species is plentiful at Locality 1650 (Calif. Acad. Sci.) in the Neptune zone of the Horsetown group on Hulen Creek, where it is associated with *Douvilleiceras mammillatum* var., *Beudanticeras breweri* (Gabb), *Puzosia subquadratum* (Anderson), and other species of middle Albian aspect. Other examples of the same genus, and perhaps species, were found in the Perrin zone at Locality 152 (Calif. Acad. Sci.), about 450 feet lower in the section, associated with *Phylloceras theresae* nov. and forms of *Sonneratia* and *Puzosia*.

No example of *D. merriami* has yet been recorded from any strata or in any association of forms that permit its reference to an Aptian horizon. Its horizon is essentially that of the Neptune zone in the upper part of the Horsetown group; it has not been found at old Horsetown itself, or in higher beds.

"Desmoceras" californicum Stanton

Desmoceras californicum STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 76, pl. 15, figs. 6, 7; about 3 miles north of Paskenta, Tehama County, and half a mile east of Henderson's.

The locality of discovery of this fossil places it very definitely within the area of the Paskenta group, although not far from its base. It is not known whether the form figured and described by Stanton under this name is properly referable to any genus of Desmoceratidae, since representatives of this family are absent or rare in the Paskenta group. In form, umbilical ratio, ribbing, septal, and other features, it is unlike any forms belonging to this family known to the writer. Stanton unfortunately compared it to a nondescript specimen figured by Gabb under the name *Ammonites breweri*, said to have been found in the uppermost beds of the Horsetown group. The comparison leaves much to be desired, and is hardly helpful. Spath has proposed the generic name *Eodesmoceras* for certain forms (group of *Ammonites celestini* Pictet and Campeche) from the Valanginian, but Stanton's species can hardly be placed in this group, which otherwise is not known in the California Cretaceous. A better specimen of an ammonite that seemed referable to *"Desmoceras" californicum* Stanton was found in nearly its horizon half a mile south of the Wilcox house, 5 miles north of Paskenta, but it could not be obtained for description. It is possible that both examples may represent some hoplitid derivative form, but neither the figure, horizon, nor description given by Stanton seems sufficient basis for a positive statement as to its family relationships.

Melchiorites Spath 1923

Melchiorites shastensis Anderson, n. sp.

(Plate 40, figures 1, 2)

Shell rather large, discoidal, moderately compressed, umbilicus moderately broad; sides of shell sloping to the somewhat narrowly rounded periphery; umbilical

walls steep, rounded above to the slightly flattened sides; surface marked by 9 or 10 slightly sinuous, rounded varices, which become more prominent near the periphery, most of which are bordered by shallow grooves; interspaces occupied by 12 or more fine radial costae, more pronounced on the outer part of the whorl; suture lines

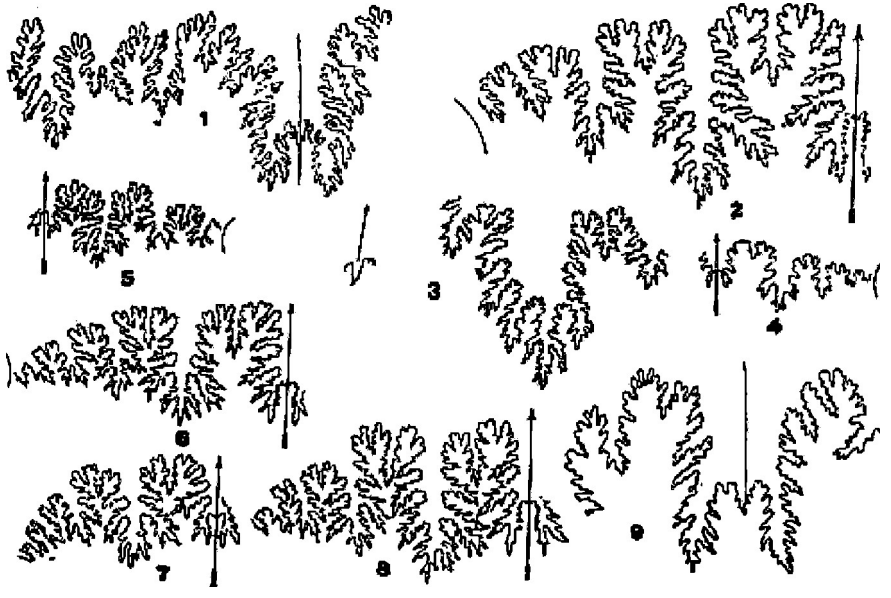

FIGURE 3.—*Suture lines*

1—Of *Acanthoplites perrini* nov. Drawn from the holotype. p. 173, pl. 33.
2—Of *Puzosia dilleri* (Anderson). p. 185, pl. 42.
3—Partial suture line of *Acanthoplites aspis* nov. Drawn from holotype. p. 171, pl. 33.
4—Of *Sonneratia stantoni* (Anderson). Drawn from young adult example. Museum of Paleontology, University of California. p. 196, pl. 49.
5—Of *Cleoniceras laconisi* (Anderson). p. 192, pl. 47.
6—Of *Puzosia subquadrata* (Anderson). p. 188, pl. 45.
7—Of *Sonneratia stantoni* Anderson. Drawn from an inner whorl of holotype. p. 196, pl. 49.
8—Of *Melchiorites indipensis* nov. p. 184.
9—Partial suture line of *Acanthoplites remondi* (Gabb). p. 172, pl. 39.
(Unless otherwise noted, suture lines were drawn from holotypes in Museum of Paleontology, University of California.)

similar to that shown in the next species. The holotype (Calif. Acad. Sci. type Coll.), septate throughout, has the following dimensions: greatest diameter, 108 mm.; width of umbilicus, 25 mm.; height of whorl, 49 mm.; thickness of whorl, 39 mm.; umbilical ratio, 0.236:1. This example and the syntype (Calif. Acad. Sci. type Coll.) were obtained at Locality 1348 (Calif. Acad. Sci.), a little above the Argonaut zone on Alderson Creek, Shasta County, associated with *Lytoceras batesi*, *Phylloceras aldersoni*, and other species, a little above the horizon of *Tropaeum percostatum* (Gabb). Examples of the species are in the Museum of Paleontology, University of California; they were apparently labelled by Gabb, "*Ammonites hoffmanni*," and were left there by the old State Geological Survey. They do not closely resemble *Puzosia hoffmanni* Gabb of the upper part of the Horsetown group. The horizon of this species is that of the Argonaut zone, or immediately above it.

Melchiorites indigenes Anderson, n. sp.

(Plate 67, figure 3; plate 68, figure 2)

Desmoceras hoffmanni Anderson (not Gabb), Calif. Acad. Sci., Pr., 3d ser., vol. 2, 1902, p. 94, pl. 5, figs. 120, 121; Cottonwood Creek, Shasta County.

In the Museum of Paleontology, University of California, there are various examples of desmoceratid ammonites left there by the old State Geological Survey, and presumably labelled by Gabb. They represent two or more species, all bearing the label "*Ammonites Hoffmanni* Gabb." As Gabb's (1864, pl. 11, figs. 13, 13a) figures are probably composite, these specimens have been the source of uncertainty. Gabb's type was said to have been found at Horsetown, where others have since been collected, including the lectotype of *Puzosia hoffmanni* (Gabb). Most of the specimens labelled by Gabb as "*Ammonites Hoffmanni*" are not very closely related to the lectotype; some of the compressed specimens, including the holotype of the present species, come under the generic group of *Melchiorites* Spath. This specimen is in the Museum of Paleontology, and was figured by Anderson. The plesiotype (Calif. Acad. Sci. type Coll.) has the following dimensions: greatest diameter, 92 mm.; width of umbilicus, 30 mm.; height of whorl, 35 mm.; thickness of whorl, 25 mm.; umbilical ratio, 0.326:1. The surface of the shell is marked by eight slightly curving varices which cross the periphery, where they become somewhat thickened. These varices are bordered before by shallow grooves, most noticeable on the periphery; between these ridges are wide interspaces occupied by six to eight rounded costae of uniform size; section of whorl flatly elliptical, broader on the lower third of the whorl; umbilicus of moderate width, with steeply sloping walls, rounded on the borders; borders often bearing bullae, which are but little prominent; suture line not unlike that of *Puzosia hoffmanni* (Gabb), as herein shown.

The figured plesiotype was found at Locality 1348 (Calif. Acad. Sci.) on Alderson Creek, associated with *Phylloceras aldersoni*, *Lytoceras batesi* (Trask), and *Tropaeum percostatum* (Gabb). Its horizon is that of the preceding species. It differs from the preceding in that it is less inflated in the lower third of the whorl, has a more rounded section at the periphery, and is comparatively smaller and smoother. The species has been found in the same horizon, associated with its congener, on Roaring River, near the Middle fork of Cottonwood Creek, and apparently on McCarthy Creek, Tehama County.

Puzosia Bayle

Species of the genus *Puzosia* occur in considerable variety in the upper part of the Horsetown group (upper Aptian to upper Albian), and continue into the Cenomanian of the lower part of the Chico series. Most of the species appear to belong to the group of *Puzosia mayoriana* (d'Orbigny), and in the order of their occurrence include: *Puzosia buenaventura* nov., *P. dilleri* (Anderson), *P. aldersona* nov., *P. subquadrata* (Anderson), *P. hoffmanni* (Gabb), and *P. jimboi* nov. Of these forms the first occurs in the lowest zone in which *Douvilleiceras mammillatum* var. has been found, and the last in the lower beds of the Chico series; the others are found in intervening strata, mostly near the middle of the Hulen beds. With *Puzosia buenaventura* are found *Puzosia recsidei* and *P. diadema* nov., which perhaps should not be included in the same group. Both the latter are thinner in section, and the first of these has fewer costae intervening between the transverse grooves; the second is smaller, has only faint constrictions, and a greater number of costae between them. *Puzosia recsidei* has some of the characters of *P. jimboi*, and others that recall *Melchiorites indigenes* of the middle Aptian. To the group of *Puzosia diadema* of the Buenaventura zone

may be added *Puzosia onona* nov. at the top of the Horsetown group. Both have the flattened, discoidal form, small umbilicus, and faintly impressed constrictions of *Puzosia communis* Spath, some of the forms of which they resemble (Spath, 1922a, figs. 3a, 3b).

Puzosia buenaventura Anderson, n. sp.

(Plate 40, figure 3; plate 41, figures 1, 2)

The shell of this species is rather large, section of whorl subcircular, umbilicus broad, walls of umbilicus abrupt below, rounded above to the curvature of the inflated side; surface of side marked by seven or eight sinuous transverse grooves which arise on the umbilical wall and cross the ventral area with a moderate forward swing; sides costate between the grooves with about 20 rounded, sinuous costae often dividing near the middle of the side; suture line resembling that of *P. hoffmanni* (Gabb). In its older stages the ribbing on the body whorl changes to a different type, developing strong and nearly straight ribs, separated by concave interspaces 20 to 30 mm. broad, showing only irregular lines of growth. The holotype (Calif. Acad. Sci. type Coll.) was found at Locality 1346-A (Calif. Acad. Sci.) on the west branch of Hulen Creek, a mile above its mouth, associated with *Douvilleiceras mammillatum* var., and other forms of *Puzosia*. The septate portion of the holotype has the following dimensions: greatest diameter, 105 mm.; width of umbilicus, 40 mm.; height of whorl, 36 mm.; width of whorl, 41 mm.; umbilical ratio, 0.381:1. The body-chamber occupies at least two-thirds of a whorl; with the body-chamber attached the diameter of the entire coil is 160 mm. This species is believed to belong exclusively in the Buenaventura zone at the bottom of the Hulen beds in this district. It has been found at the same horizon on Alderson Creek, 2 miles south of Ono, and fragmentary examples have been found on Dry Creek, west of Rosewood.

Puzosia dilleri (Anderson)

(Plate 43, figures 1, 2, 3; plate 46, figure 1)

Desmoceras dilleri Anderson, Calif. Acad. Sci., Pr., 3d ser., vol. 2, 1902, p. 97, pl. 4, figs. 116, 117; pl. 10, fig. 192; Cottonwood Creek, Shasta County.

This species is rather large, discoidal, a little compressed; umbilicus broad, not deep, walls abrupt below, rounded above, merging with the rounded sides; section of whorl broadly semi-elliptical, with sides tending to converge toward the periphery; surface marked by six slightly sinuous, shallow grooves which arise on the umbilical walls and cross the ventral area with only a slight sinus; interspaces between the grooves occupied by 18 to 20 low, rounded costae; suture as shown. The holotype of this species is in the Museum of Paleontology, University of California. It is wholly septate and has the following dimensions: greatest diameter, 115 mm.; width of umbilicus, 45 mm.; height of whorl, 45 mm.; thickness of whorl, 46 mm.; umbilical ratio, 0.391:1. This species is intermediate in form, surface ornamentation, and stratigraphical position, between *P. buenaventura* and *P. hoffmanni* (Gabb). It is not unlikely that the line of descent includes the three forms; this line may terminate above in *P. jimboi* nov. (= *Puzosia ishikawai* Smith, not Jimbo). The holotype of *P. dilleri* was found by the writer on the east branch of Hulen Creek, about 400 feet beneath the Perrin zone and therefore about 1500 feet below the top of the Horsetown group. Two additional specimens are in the collections of the California Academy of Sciences, obtained from Locality 1668 (Calif. Acad. Sci.) from a somewhat higher horizon than that of the holotype; its stratigraphic position is in the lower part of the Hulen beds (lower Albian) in this district.

Puzosia subquadrata (Anderson)

(Plate 45, figures 3, 4, 5)

Desmoceras subquadrata ANDERSON, Calif. Acad. Sci., Pr., 3d ser., vol. 2, 1902, p. 96, pl. 4, figs. 118, 119; pl. 10, fig. 193; Cottonwood Creek, Shasta County, upper part of Horsetown group.

This species is closely related to *P. dilleri* but differs in form and ornamentation, having no transverse grooves or only faint traces of them. The ribs are more nearly uniform in size and somewhat coarser than the minor ribs of the preceding species. The holotype is in the Museum of Paleontology, University of California. The plesiotype (Calif. Acad. Sci. type Coll.) has the following dimensions: greatest diameter, 102 mm.; width of umbilicus, 34 mm.; height of whorl, 43.3 mm.; width of whorl, 40 mm.; umbilical ratio, 0.333:1. This example was obtained at Locality 1659 (Calif. Acad. Sci.) on the east branch of Hulen Creek, in the Neptune zone, associated with *Douvilleiceras mammillatum* var., *Beudanticeras breweri* (Gabb), *Lytoceras neptunium* nov., and many other species. Its horizon is regarded as upper-middle Albian. This species is among the number indicated by Kilian and Reboul (1900, p. 25) as being referable to *Kossmaticeras* Grossouvre, but it is not apparent that that genus, or that any of the subgenera sought to be established by these authors, has representatives in the Lower Cretaceous of California. No species mentioned by them can properly be regarded as within the legitimate limits of either form or horizon assigned to *Kossmaticeras*, as defined by Grossouvre or by themselves. The genus, as indicated by its author, should be restricted to Upper Cretaceous strata.

Puzosia aldersona Anderson, n. sp.

(Plate 39, figure 2)

Shell robust, large, slightly compressed; umbilicus of moderate width, bordered by steep walls, rounded above; section of whorl broadly elliptical, higher than broad; surface marked by five nearly straight, or slightly curved, shallow transverse grooves, bordered by ridges which, on the shell, form only a slight sinus in the ventral area; interspaces between grooves occupied by about 20 to 22 rounded costae; suture lines crowded, but similar to those of *P. hoffmanni* (Gabb). This species is closely related to *P. dilleri* (Anderson) but it is more robust, has a smaller umbilical ratio, and increases more rapidly in size, having a higher whorl section. Its horizon is above that of *P. dilleri* and below that from which the type of *P. hoffmanni* came. The holotype (Calif. Acad. Sci. type Coll.), septate throughout, has the following dimensions: greatest diameter, 180 mm.; width of umbilicus, 53 mm.; height of whorl, 77 mm.; width of whorl, 65 mm.; umbilical ratio, 0.295:1.

The holotype was found on Alderson Creek, 2 miles south of Ono, in the upper part of the Horsetown group (upper-middle Albian), a little below the horizon of *Oxytropidoceras packardi* nov.; it has not been found in any other horizon. Two fairly good examples were found at the type locality. This is one of the largest species of *Puzosia* yet found in the Cretaceous of California. It has some resemblance to *P. matheroni* (d'Orbigny), from the lower Aptian of France, but its critical measurements are different, and its stratigraphical position is much higher.

Puzosia hoffmanni (Gabb)

(Plate 45, figures 1, 2)

Ammonites Hoffmanni GABB, Paleont. Calif., vol. 1, 1864, p. 65, pl. 11, figs. 13, 13a; pl. 12, fig. 13b; Horsetown, Shasta County—STANTON, Geol. Soc. Am., Bull., vol. 4, 1893, p. 250, 251; locality as above.

Desmoceras hoffmanni STANTON, Geol. Soc. Am., Bull., vol. 5, 1894—ANDERSON, Calif. Acad. Sci., Pr., 3d ser., vol. 2, 1902, p. 94 (in part), pl. 10, fig. 203; Cottonwood district, Shasta County (not pl. 5, figs. 120-123); upper beds of the Horsetown group, Horsetown, Shasta County.

The holotype of this species seems to have been lost, and it is therefore permissible to choose a lectotype. Gabb's original figures of the species seem to be composite, and to be based upon more than one species, and therefore are defective. The lectotype (Calif. Acad. Sci. type Coll.) has the following dimensions: greatest diameter, 86 mm.; width of umbilicus, 31.5 mm.; height of whorl, 35 mm.; thickness of whorl, 30 mm.; umbilical ratio, 0.336:1. This specimen was obtained at the old mining camp of Horsetown and is the only form of *Puzosia* found there that can properly represent Gabb's species. In this lectotype the section of the whorl is more inflated than in Gabb's figures; the constrictions are broad and are bordered behind by a rounded ridge; there are usually six or seven constrictions on a single whorl; they are flexiradiate, curving at first forward near the umbilical border, then gently backward to above the middle of the side, then forward again, crossing the ventral zone with a forward sinus; between the constrictions the surface is marked by 18 to 22 rounded costae, all of which cross the ventral zone. The walls of the umbilicus are abrupt below, rounded above, the curvature merging into that of the slightly inflated sides. The examples of this species obtained by the writer from the type locality may be regarded as topotypes; most of them have only six constrictions, and all have fewer than are shown in Gabb's drawings, but the measurements given above do not differ materially from those obtained from his figures.

This species appears to belong to the group of *Puzosia mayoriana* (d'Orbigny), as seen in its external form, ornamentation, and sutural characters. Other examples of the species have been obtained from Locality 1650 (Calif. Acad. Sci.) in the Neptune zone on Hulen Creek, and on Bee Creek, and on the North fork of the Cottonwood Creek.

Puzosia reesidei Anderson, n. sp.

(Plate 38, figures 2, 3)

This is one of the smaller forms of *Puzosia* from the Hulen beds of the Cottonwood district. The shell is discoidal, compressed, moderately involute, with flattened sides, narrowly rounded periphery, which becomes slightly flattened in mature stages of growth; whorls costate, with low sigmoid costae, and about eight rather narrow constrictions crossing the sides obliquely; umbilical walls smooth or polished; the younger stages are more strongly costate than those of later stages. In form and ornamentation the species differs from any of its congeners, and is distinguished by its flattened sides and its strongly inclined costal features. The suture lines are not well shown. The holotype (Calif. Acad. Sci. type Coll.) was found at Locality 1346-A (Calif. Acad. Sci.) in the Buenaventura zone, associated with *P. buenaventura*, *Douvilleiceras mammillatum* var., and *Silesites puzosiaformis* nov.

The holotype has the following dimensions: greatest diameter, 49 mm.; width of umbilicus, 15 mm.; height of whorl, 21 mm.; thickness of whorl, 14 mm.; umbilical ratio, 0.306:1. The paratype (Calif. Acad. Sci. type Coll.), a smaller and relatively thicker form, was found at the same locality. Although the species seems to belong to the group of *P. mayoriana* (d'Orbigny) it differs from other members of this group. It may represent a transitional form between *Melchiorites shastensis* nov. and later forms of *Puzosia*, ? group of *P. onona* nov. in the uppermost Horsetown beds.

Spath (1922, p. 127) proposed the generic name *Kilchinites* for forms similar to this and the following four species.

Puzosia diadema Anderson, n. sp.

(Plate 42, figures 9, 10, 11, 12)

The four examples of this species are small, discoidal compressed, with moderate or small umbilicus and fine sinuous costae; umbilical walls sloping, rounded above and merging into the convex sides; surface of sides marked by three or four shallow, flexuous grooves, inclining forward, and crossing the ventral zone with a forward sinus; interspaces between grooves occupied by 20 or more fine costal lines; section of whorl narrowly elliptical. The holotype (Calif. Acad. Sci. type Coll.), almost wholly septate, has the following dimensions: greatest diameter, 20 mm., width of umbilicus, 5 mm.; height of whorl, 9 mm.; thickness of whorl, 6 mm.; umbilical ratio, 0.240:1.

The diameter of the syntype is 16 mm.; thickness of whorl, 5 mm. All the examples were found at Locality 1346-A (Calif. Acad. Sci.), a mile above the mouth of Hulen Creek, on the west branch, associated with *Puzosia buenaventura* and *Douvilleiceras mammillatum* var., in the Buenaventura zone, in the lower part of the Hulen beds. The form may be the precursor of *Puzosia onona* nov.

Puzosia jimboi Anderson, n. sp.

(Plate 42, figures 5, 6, 7)

Desmoceras ishikawai SMITH (not JIMBO), Calif. State Min. Bur., Bull. 69, 1914, Folio, opp. front cover, fig. 6; Jackass Flat, near Horsetown, Shasta County.

Shell small, discoidal, compressed, numerously costate; umbilicus of moderate width, walls abrupt, rounded above; surface marked by eight slightly sinuous grooves arising on the umbilical wall and crossing the ventral area with a forward sinus; younger whorls not showing grooves or costae crossing the periphery; interspaces between grooves occupied by six or more small rounded costae, often dividing at the umbilical border, or near the middle of the side, and stronger on the upper part of the whorl; sutures not known. The holotype (Calif. Acad. Sci. type Coll.), half septate, has the following dimensions: greatest diameter, 23 mm.; width of umbilicus, 7 mm.; height of whorl, 10 mm.; thickness of whorl, 9 mm.; umbilical ratio, 0.304:1. The largest example of this species yet seen measures 40 mm. in diameter. The paratype (Calif. Acad. Sci. type Coll.) has the following dimensions: greatest diameter, 19 mm.; thickness of whorl, 7 mm. The horizon is that of the uppermost Horsetown group. Many examples were found in 1898 at Jackass Flat, a mile east of Horsetown; most of these were lost in the San Francisco fire of 1906. The holotype was among those recovered. The species differs from "*Desmoceras*" *ishikawai* Jimbo (1894) in section, being relatively thinner, the umbilicus being much smaller; it also has a greater number of transverse grooves; it also has only about 50 costae to the whorl. The horizon of the present species is not younger than upper Albian, whereas Jimbo's species is much later, perhaps Senonian.

Puzosia onona Anderson, n. sp.

(Plate 42, figure 8)

This species occurs with the preceding in the uppermost beds of the Horsetown group in the Cottonwood district. The shell is small, discoidal, compressed, flattened on the sides, numerously costate; umbilicus small, walls abrupt, rounded on the border; surface marked by five or more faint sinuous grooves which cross the ventral area with a distinct forward sinus; interspaces occupied by eight or more fairly well marked, rounded costae; suture line not shown. The holotype (Calif. Acad. Sci. type Coll.), mostly septate, has the following dimensions: greatest diam-

eter, 30 mm.; width of umbilicus, 8 mm.; height of whorl, 12 mm.; thickness of whorl, 10 mm.; umbilical ratio, 0.267:1. The paratype (Calif. Acad. Sci. type Coll.) measures: diameter, 15 mm.; thickness of whorl, 4 mm. Both of these examples were found in 1898 at Jackass Flat, a mile east of Horsetown, Shasta County, and were among those recovered from the San Francisco fire of 1906. This species resembles *Puzosia diadema*, from the Buenaventura zone, and it may be regarded as a lineal successor from it.

Puzosia weaveri Anderson, n. sp.

(Plate 42, figure 4)

Shell small, discoidal, compressed, and numerously costate; umbilicus relatively broad, walls not abrupt, but rounded on the border, curving to the convex sides; sides marked by about five transverse, shallow grooves, inclining forward and crossing the ventral area with a forward sinus; interspaces between grooves occupied by eight to ten rounded costae, separated by equally broad rounded hollows; section of whorl narrowly elliptical; suture line desmoceratid, although not completely exposed. The holotype of the species is in the Museum of Paleontology, University of California, and was loaned for study and description through the courtesy of Dr. B. L. Clark, to whom the author is indebted for information as to its occurrence. It is well preserved in part, and has the following dimensions: greatest diameter, 55 mm.; width of umbilicus, 19 mm.; height of whorl, 20 mm.; thickness of whorl, 20 mm.; umbilical ratio, 0.345:1. This example was found at the Fernandez tunnel on the Santa Fe Railroad, about 3 miles east of Rodeo, Contra Costa County. Its horizon is not yet definitely known, but it is presumably from beds of upper Horsetown age, although they may be younger. The beds appear to be nearly equivalent to those southeast of Crocket, from which a large fragment of *Acanthoplites* has been obtained. The species is named for Dr. C. E. Weaver, in recognition of valuable contributions made to the geological and paleontological literature of California and of other western States. One or two additional ammonoid species of upper Horsetown age have been reported from the neighborhood of this tunnel.

Beudanticeras Hitzel

Beudanticeras breweri (Gabb)

(Plate 43, figure 3; plate 44, figures 1, 2)

Ammonites Breweri Gabb, Paleont. Calif., vol. 2, 1869, p. 130, pl. 20, fig. 5; pl. 19, fig. 5b, only, (not figs. 6, 6a); Cottonwood Creek, Shasta County.

Desmoceras breweri Stanton, Geol. Soc. Am., Bull., vol. 5, 1894, p. 446; Horsetown Beds—(?) Whiteaves, Geol. Surv. Canada, Mes. Foss., vol. 1, pt. 4, 1900, p. 284; Maude Island—Anderson, Calif. Acad. Sci., Pr., 3d ser., vol. 2, 1902, p. 62; Horsetown Beds, Shasta County.

Gabb's (1864, pl. 10) original figure and description of this species were quite defective, and he apparently abandoned them. In the second volume of his work (Gabb, 1869a), he gave a new figure and an emended description which better represents the species. The holotype is in the collections of the Academy of Natural Sciences of Philadelphia and was loaned for re-figuring and description, through the courtesy of Dr. H. A. Pilsbry. The species is abundant in the upper part of the Horsetown group on Hulen Creek and on the North fork of Cottonwood Creek. Many examples of all sizes belonging to this species were collected at Locality 1659 (Calif. Acad. Sci.) in the Neptuno zone on Hulen Creek and also at the old mining camp at Horsetown, on Clear Creek. Many examples of the species are in the Museum of Paleontology, University of California, and others are in the collections of Stanford University. With

but little variation they conform to the dimensions and sculptural features of the holotype, which measures as follows: greatest diameter, 122 mm.; width of umbilicus, 36 mm.; height of whorl, 52 mm.; thickness of whorl, 32 mm.; umbilical ratio, 0.295:1. The species is found at other localities on the west border of the Great Valley embayments as far south as Puerto Creek, but not abundantly. In the Neptune zone on Hulen Creek it is associated with *Desmoceras merriami* (Anderson), *Lytoceras neptunium* nov., *Lytoceras aurarium* nov., and *Douvilleiceras mammillatum* var. Its chronological horizon is regarded as upper-middle Albian, and its stratigraphic position is about 450 feet below the top of the Horsetown group at this locality on the east branch of Hulen Creek.

The species grew to a considerable size; fragments of it have been found that represent examples having a diameter of more than one foot (305 mm.), and a thickness of 2 inches or more. In old age most of the ribs became obsolete.

A small example of the species has been sent to the California Academy of Sciences by Dr. J. B. Reeside from a locality "west of the big bend of Young Creek, Chitina Valley, Alaska," elevation 3450 feet.

Beudanticeras hulenense Anderson, n. sp.

(Plate 44, figures 3, 4)

This species is closely related to the preceding and occurs with it in many places; it differs from it in its smoother surface, smaller umbilicus, and thinner section. The shell is without conspicuous ribs and is often quite smooth; the umbilical walls are abrupt, angulated at the top at its juncture with the flattened sides; surface marked by faint growth lines which cross the ventral area, occasionally forming a varex-like ridge on the periphery which has a slight sinus; surface markings irregularly spaced. The holotype (Calif. Acad. Sci. type Coll.), partly septate, has the following dimensions: greatest diameter, 125 mm.; width of umbilicus, 35 mm.; height of whorl, 53 mm.; thickness of whorl, 32 mm.; umbilical ratio, 0.280:1. In the collections of the California Academy of Sciences there are 25 or more examples representing nearly all sizes of whorl. They were obtained at Locality 1659 (Calif. Acad. Sci.), on the east branch of Hulen Creek, Shasta County. With little variation they conform to the dimensions and sculptural characters of the holotype. The same species has been collected at Horsetown and at other points in the Cottonwood district; it occurs at the same horizon in western Glenn County and on Elder Creek, Tehama County. An example was found by J. A. Taff and G. D. Hanna on Elder Creek, in a boulder buried in the basal conglomerate of the Chico series, evidently derived from the upper part of the Horsetown group. Its horizon is thought to be that of the Neptune zone, in which it occurs in its type district.

Beudanticeras haydeni (Gabb)

(Plate 48, figures 2, 3)

Ammonites Haydeni Gabb, Paleont. Calif., vol. 1, 1864, p. 62, pl. 10, figs. 8, 8a; North fork of Cottonwood Creek, Shasta County.

Desmoceras (Puzosia) Haydeni Whiteaves, Geol. Surv. Canada, Mes. Foss., vol. 1, pt. 4, 1900, p. 285; Maude Island, Queen Charlotte Islands—Anderson, Calif. Acad. Sci., Pr., 3d ser., vol. 2, 1902, p. 41; Horsetown beds, Shasta County.

According to Gabb's description, and as observed by the writer, the shell of this species is compressed, thin, and discoidal, flattened on the sides and narrowly rounded on the periphery; umbilicus relatively small, with abrupt walls. Flattening of the ventral zone is rarely if ever seen, although Gabb notes this feature in his description. The species is more frequently found in the basal beds of the Chico

series, but has been recorded from the upper part of the Horsetown group associated with the preceding. Its occurrence in concretionary blocks in the near basal conglomerates of the Chico series at the mouth of Hulen Creek lends support to the belief that it occurs in the upper beds of the Horsetown group. The holotype is in the Museum of Paleontology, University of California, and has been loaned for comparison with the figured plesiotype from Horsetown, Shasta County. The plesiotype (Calif. Acad. Sci. type Coll.) has the following dimensions: greatest diameter, 57 mm.; width of umbilicus, 12 mm.; height of whorl, 28 mm.; thickness of whorl, 14 mm.; umbilical ratio, 0.211:1.

The species has been found abundantly at Horsetown and at Texas Springs. It is usually without surface ornamentation, and is often smooth or polished.

Silesites Uhlig 1903

Silesites puzosiaformis Anderson, n. sp.

(Plate 20, figures 9, 10)

Two fairly well preserved examples of this genus were found in the Buenaventura zone in the lower part of the Hulen beds at Locality 1346-A (Calif. Acad. Sci.) on the west branch of Hulen Creek, Shasta County. They represent a single species. The shell is small, discoidal, compressed, and broadly umbilicate; section of whorl narrowly elliptical, with gently convex sides, sloping toward the periphery; sides marked by slightly sinuous transverse grooves unequally spaced, which cross the ventral zone with a forward sinus; between the grooves are 7 to 12 narrow costae concentric with them, also crossing the periphery without interruption. The holotype (Calif. Acad. Sci. type Coll.) has the following dimensions: greatest diameter, 22 mm.; width of umbilicus, 8 mm.; height of whorl, 8 mm.; thickness of whorl, 5.5 mm.; umbilical ratio, 0.381:1.

This species very closely resembles *Silesites desmoceratoides* Stolley from Lago San Martin, western Patagonia, to which it seems to be closely related. Stolley did not definitely determine the age of the beds containing this species but thought they were probably upper Neocomian, citing the view of Ch. Jacob, however, that the genus *Silesites* is not confined to the Barremian stage but may occur in Aptian, or even in Albian strata in the south of France. At the type locality of our species in the Cottonwood district, it occurs in the same beds with *Douvilleiceras mammillatum* var., *Puzosia buenaventura*, and other species that range higher in the section. The genus *Silesites* is rare in the Cretaceous of California, this being the only record of its occurrence. Fragmentary specimens that may pertain to the genus have been found in beds farther south that are regarded as Aptian. Whiteaves described a small form of similar appearance to which he gave the name "*Holcodiscus*" *laperousianus*, reported to have come from the east end of Maude Island (Whiteaves, 1879, p. 39, pl. 3, fig. 3). According to Stanton (MacKenzie, 1916, p. 65) the formation may not be older than Gault.

Holcodiscus Uhlig 1883

Genotype, *Ammonites caillaudianus* d'Orbigny

Holcodiscus tehamaensis Anderson, n. sp.

(Plate 23, figure 5)

Shell large, coiling lytoceratid, little involute, numerously costate with major and minor ribs and about 24 periodic constrictions to a mature whorl; constrictions bordered on both sides by elevated ridges bearing irregular elongated spurs (on the cast), four on each side; surface of shell between major costae bearing 4 to 8 inter-

mediary finer costae, slightly flexed on the side and crossing the ventral zone without interruption; umbilicus broad, section of whorl broadly elliptical, a little compressed; ribs arising on the umbilical wall with a slight flexure, rectiradiate on the sides, or slightly flexuous. This species has the general features of, and somewhat resembles, the genotype of *Holcodiscus* Uhlig, from the Wernsdorfer beds, although larger. It has even greater resemblance to *H. seunesi* Kilian (1910, pl. 7, fig. 2) from the Barremian (Montagne de Lure) of France, from which it differs chiefly in its more flexuous costae.

The holotype, No. A-2934 (Univ. Calif. Coll.), consisting of a large fragmentary example, was found by R. L. Rist on McCarthy Creek in the lower part of the Horsetown group (lower Barremian), about a third of a mile west of the Paskenta-Lowry road. The holotype has the following dimensions: greatest diameter, 250 mm.; width of umbilicus, 135 mm. (?); height of whorl, 75 mm.; thickness of whorl, 60 mm.; suture lines not exposed.

Cleoniceratidae Whitehouse 1926

Whitehouse includes in this family *Cleoniceras* Parona and Bonarelli, *Sonneratia* Bayle, emend. Spath, and other genera not known in California. The genera here named are plentiful in the Hulen beds, in strata regarded as middle Albian. As found here these genera appear to be closely related, as seen in their forms, ornamentation, and suture lines, and they are found in a relatively limited stratigraphical range of 400 feet; in fact, examples of the two genera have been found within a distance of 20 feet, although not mingled in the same stratum. The forms referred to *Cleoniceras* are lower in the section than *Sonneratia*. The more prolific horizons are about 250 feet apart. The relationship of these genera to desmoceratids is not entirely clear but, as judged by their more important characters, they belong in the same lineage. Their stratigraphical position is intermediate between *Melchiorites* (middle Aptian) and forms of *Beudanticeras* (upper-middle Albian), and all appear to have genetic relationship with Hoplitidae. The relationship of *Cleoniceras* to *Beudanticeras* seems to have been recognized by Spath (1923, p. 37), wherein he says, in part:

> "*Cleoniceras*, Parona and Bonarelli, with which genus *A. beudanti* was first included, represents a short-lived parallel development, but on account of its strong ornamentation is here included in Hoplitidae. The suture lines are closely comparable in all these forms until reduced, and as Dr. Kitchin has pointed out, the suture lines of the species here included in *Beudanticeras* and those of *Cleoniceras* show good agreements with those of the true *Desmoceras* (*Latidorsella*, Jacob), and the corresponding globose development."

It may be added that the suture lines of *Sonneratia sacramentica*, *Puzosia subquadrata*, *Melchiorites shastensis*, and *Desmoceras merriami* are very similar.

Cleoniceras leconteï (Anderson)

(Plate 38, figure 4; plate 47, figures 3, 4, 5)

Desmoceras leconteï Anderson, Calif. Acad. Sci., Pr., 3d ser., vol. 2, 1902, p. 95, pl. 3, figs. 94, 95; pl. 10, fig. 190; east branch of Hulen Creek, Shasta County.

The holotype of this species is in the Museum of Paleontology, University of California; a photographic figure of it is here given. The shell is of moderate size, discoidal, compressed, deeply involute, narrowly umbilicate; umbilical walls steep, nearly smooth, forming right angles with the sides; sides flattened, costate, with numerous flexiradiate, rounded costae, which divide a little above the middle of the side, sometimes branching into three sub-peripheral costae; interspaces rounded, equal in width to the costae. The holotype of the species has the following dimen-

sions: greatest diameter, 72 mm.; width of umbilicus, 15 mm.; height of whorl, 35 mm.; thickness of whorl, 26 mm.; umbilical ratio, 0.177:1. The costae do not continue across the periphery as a rule, although some of the varices do so with a slight forward curve, the number being about one to ten costae. These varices do not appear below a diameter of 35 mm., and often 30 mm. or more, as measured on the periphery, intervene between them. This and the following species somewhat resemble forms of *Beudanticeras*, but they differ from those of this genus found higher in the section, in having a relatively smaller umbilicus and a more convex lenticular section.

Cleoniceras lecontei is found in considerable numbers in a restricted zone about 1000 feet below the top of the Horsetown group on Hulen Creek. It has not yet been found or recorded at any other horizon in the Cottonwood district or elsewhere.

Cleoniceras modestum Anderson, n. sp.

(Plate 50, figures 2, 3, 4)

In size and form this species is near the preceding, but lacks its more pronounced ornamentation, being either smooth or only faintly costate and showing on its sides only traces of flexiradiate markings, scarcely to be called costae, even on the shell itself; periphery narrow, crossed only by a number of weak varices, having a forward sinus but scarcely extending downward on the sides; the shell is discoidal, the sides flattened; umbilicus small, with abrupt and smooth walls; sides sloping toward the periphery. In young stages of growth the shell is relatively thicker and more desmoceratid in form, but in more mature stages it becomes more flatly lenticular and smooth, as in the holotype. In form the shell is intermediate between *Cleoniceras lecontei* and some forms of *Beudanticeras*, as seen in *B. haydeni* (Gabb). The holotype (Calif. Acad. Sci. type Coll.) has the following dimensions: greatest diameter, 80 mm.; width of umbilicus, 15 mm.; height of whorl, 39 mm.; thickness of whorl, 24 mm.; umbilical ratio, 0.187:1.

The suture line is partly shown in the figure and resembles that of the preceding species. The horizon of this form is the same as that of *C. lecontei*—that is, in or immediately above the Perrin zone, as found in the Hulen Creek section of the Cottonwood district.

Sonneratia Bayle, emend. Spath, emend. Whitehouse

Genotype, *Ammonites dutempleanus* d'Orbigny

Adopting the suggestion of Spath (1925, p. 93), the writer here includes a group of related species which occupy a stratigraphic position intermediate between middle Aptian forms of *Parahoplites* and middle Albian species of *Beudanticeras*, as found in the Cottonwood district of California. It appears that in character also, as well as in position, they are intermediate between these genera, although they foreshadow the latter more clearly than they reflect the former. They are provisionally placed in *Sonneratia*, as having their nearest European analogues in the group of *"Uhligella" balmensis* (Jacob), which, according to Spath, "might with propriety be included in *Sonneratia*." Their stratigraphical position follows closely upon the principal zone of *Cleoniceras*, and some of the forms such as *Sonneratia rogersi* Hall and Ambrose could perhaps be placed in this genus. It is not claimed that any of the species here described belongs to the group of *Ammonites dutempleanus*, but rather to that of *"Uhligella" balmensis* (Jacob), as already noted.

For the proper assignment of the California forms the greatest practical difficulty seems to be in the matter of finding a satisfactory distinction between *Cleoniceras* and *Sonneratia* on the one hand, and between *Cleoniceras* and *Beudanticeras* on the

other. This difficulty is in no way clarified by the taxonomic record of the leading species of the group—namely, *Sonneratia sacramentica*—originally described as "*Pachydiscus*" *sacramenticus* Anderson. Spath (1922, p. 125) noted this evident error and has referred the species to "*Pleuropachydiscus*" Hyatt, which appears to be a *nomen nudum*. The genotype of this proposed group is the "thicker form" described by Gabb (1869a, p. 131) as *Ammonites hoffmanni*, a species found in a higher horizon—the upper-middle Albian—which has little relation to *Sonneratia sacramentica*.

Sonneratia sacramentica (seq.) bears evidence in its younger stages of being strictly congeneric with the following species placed under the genus; it also seems to belong to the group of "*Uhligella*" *balmensis* (Jacob), as already indicated. The views of Spath (1923, p. 35, 36) seem to be illustrated by the following texts:

"Since Parahoplitidae and Hoplitidae are considered to be trachyostracous developments of Desmoceratidae, it may be convenient on account of their tuberculation, to remove from Desmoceratidae the genus *Cleoniceras* (with which is included "*Uhligella*" *balmensis* (Jacob)), and *Sonneratia*, though they are directly connected with "*Uhligella*," and *Beudanticeras*, and show the same type and variability of the suture-line as does *Desmoceras s. s.* (= "*Latidorsella*," Jacob)."

"Certain Aptian *Pleuropachydiscus* are often wrongly referred to "*Latidorsella*," ? *i.e.*, *Desmoceras s. s.*"

These views seem to be somewhat modified in a later paper, from which we learn in his discussion of *Cleoniceras baylei* (Spath, 1925, p. 93):

"The species is included in *Cleoniceras* rather than in *Sonneratia* on account of the smoothness of its adult stage and the disappearance of the ribbing on the venter. It probably represents a direct development of "*Uhligella*" *balmensis* (Jacob) which is far more strongly costate, and might with propriety be included in *Sonneratia*, although its suture-line is still in the '*Desmoceras*' stage."

Sonneratia perrinsmithi Anderson, n. sp.

(Plate 51, figures 5, 6, 7)

Shell of moderate size, discoidal, moderately compressed; umbilicus not broad, with somewhat abrupt walls, slightly angulated on the border; sides slightly flattened or flatly rounded, numerously costate; costae "prorsiradiate," branching above the middle of the side into two or three rounded ribs, curving strongly forward, and crossing the ventral zone with only slight weakening, as seen on the cast; tubercules on the umbilical borders much reduced.

This species is distinguished by its greater number of ribs and by the method of their branching; there are about 82 ribs at the ventral border. The ventral zone is rounded or only faintly flattened in the younger stages. The holotype (Calif. Acad. Sci. type Coll.) has the following dimensions: greatest diameter, 100 mm.; width of umbilicus, 35 mm.; height of whorl, 32 mm.; umbilical ratio, 0.35:1. This specimen was obtained at Locality 152 (Calif. Acad. Sci.) on the east branch of Hulen Creek, associated with *Sonneratia sacramentica* and *S. taffi* nov., and *Douvilleiceras mammillatum* var. at a horizon about 900 feet below the top of the Hulen beds of the Horsetown group. Its horizon appears to be middle Albian.

Sonneratia taffi Anderson, n. sp.

(Plate 49, figures 4, 5)

This species bears some resemblance to *S. perrinsmithi* but is smaller, has a smaller umbilicus and only about 56 to 60 costae; ventral zone smoother and less strongly costate than the preceding; suture line only imperfectly shown on the holotype.

The horizon of this species is that of the Perrin zone, at Locality 152 (Calif. Acad.

Sci.) on the east branch of Hulen Creek, where it was associated with the preceding, and with *Phylloceras theresae*, and the other species of this locality, including *Douvilleiceras mammillatum*, var., 900 feet below the top of the Horsetown group. The holotype (Calif. Acad. Sci. type Coll.) affords the following measurements: greatest diameter, 74 mm.; width of umbilicus, 24 mm.; height of whorl, 30 mm.; width of whorl, 24 mm.; umbilical ratio, 0.324:1.

This species is named in honor of J. A. Taff, whose work and cooperation in the field explorations in Shasta and Tehama counties, in the vicinity of Mount Diablo, Contra Costa County, and in the Diablo Range, have been of much value and importance in stratigraphic determinations and measurements.

Sonneratia mulleri Anderson, n. sp.

(Plate 51, figure 4; plate 54, figures 3, 4)

Shell small, discoidal, compressed, umbilicus moderately broad; sides somewhat flattened, strongly costate, with "prorsiradiate" costae in two ranks; major costae arising on the umbilical border in bullae from which they branch into two, or rarely three, curving strongly forward, especially upon the ventral border; minor ribs arising near the umbilical border without nodes, branching into two costae; all ribs crossing the ventral border without interruption, although weakened, and with a pronounced sinus; section of whorls thinner than in the preceding species. This species seems to be somewhat close to *Sonneratia rogersi* in form and ornamentation, although it has a wider umbilicus and fewer ribs. The holotype (Calif. Acad. Sci. type Coll.) has the following dimensions: greatest diameter, 35 mm.; width of umbilicus, 11 mm.; height of whorl, 13 mm.; width of section, 12 mm.; umbilical ratio, 0.314:1. This example was found at Locality 152 (Calif. Acad. Sci.) in the Perrin zone, where it occurs sparingly with others of the same genus. Another example of the same species was found by S. W. Müller in the same zone farther to the west on Hulen Creek. The species is named for this enthusiastic worker.

Sonneratia sacramentica (Anderson)

(Plate 49, figures 1, 2, 3)

Pachydiscus sacramenticus Anderson, Calif. Acad. Sci., Pr., 3d ser., vol. 2, 1902, p. 105, pl. 6, figs. 133, 134; pl. 10, fig. 195; east branch of Hulen Creek, Shasta County.

Shell moderate in size, discoidal, not strongly compressed, section of whorl inflated in older stages, sides rounded; sloping toward the rounded periphery; umbilicus moderately broad, walls sloping steeply below, rounded above to meet the gently inflated sides; involution moderate, embracing half of the inner whorl; body-chamber occupying two-thirds of the last whorl; sides almost smooth on the umbilical border, costate on the upper part of the whorl with sharp, slightly sinuous ribs inclining forward near the outer border, ribs in the older stages most prominent above the middle of the side separated by wider interspaces, not noded on the umbilical border, and tending to diminish in strength in the ventral zone; section of whorl in the body-chamber subelliptical, showing the inflated form of *Sonneratia kitchini* Spath, but possessing a somewhat broader umbilicus. In its younger stages the shell has more nearly the form and ribbing of *Sonneratia* sp. ind. Spath (1925, p. 90, pl. 6), which is less inflated and more closely costate than *S. kitchini*. It also shows nodes near the umbilical border, and dividing ribs, similar to those in the young shell of the species here described. The suture line of *S. sacramentica* as shown in the original description, and here reproduced, may be somewhat emended, in that the saddles show a less rapid slope toward the dorsum than is shown in the figure.

The holotype (Univ. Calif. Coll.) has the following dimensions: greatest diameter,

102 mm.; diameter of umbilicus, 32 mm.; height of whorl, 43 mm.; width of whorl, 36 mm.; umbilical ratio, 0.313:1.

The inner whorls are more compressed than the outer whorls, and the ribs tend to develop tubercules on the umbilical borders, which later disappear, leaving the border of the older whorls smooth. Only three examples of this shell have been found. Its horizon is near that of its congeners, which is about 900 feet below the top of the Horsetown group in the Hulen Creek district. The holotype was found in the Perrin zone at Locality 152 (Calif. Acad. Sci.) on the east branch of Hulen Creek, where it was associated with *Desmoceras merriami*, *Douvilleiceras mammillatum* var., and *Phylloceras theresae* nov. Spath has referred *S. sacramentica* (Anderson) to "*Pleuropachydiscus*" Hyatt, whose genotype is *Desmoceras merriami* (Anderson), to which it has little resemblance except in the character of the suture lines. The name "*Pleuropachydiscus*" Hyatt is clearly a *nomen nudum*.

Sonneratia stantoni Anderson

(Plate 50, figures 5, 6, 7)

Sonneratia stantoni ANDERSON, Calif. Acad. Sci., Pr., 3d ser., vol. 2, 1902, p. 105, pl. 3, figs. 91–93; pl. 10, fig. 108; Horsetown, Shasta County, California.

The original description of this species, somewhat emended, reads in part as follows:

"Shell small, not often above a diameter of 35 mm.; discoidal, laterally compressed and flattened; sides converging gently toward the periphery; ventral surface rounded or subquadrate; umbilicus not large, less than one-third the total diameter, generally funnel-form, due to its sloping sides and the increasing thickness of the whorls; surface ornamented by about 30 transverse flexuous ribs which usually cross the ventral surface, arising at the umbilical border in distinctly tuberculate nodes, from which they branch in pairs. The surface of the shell, both on the ribs and in the interspaces, shows fine striae, always parallel to the ribs. The suture line is simple, consisting of a few broadly rounded saddles, and wide lobes with very short branches. The saddles are but little indented, are divided by rounded incisions; lobes unequally tripartite."

This species was once abundant at Horsetown, and many were collected at this place by the writer but most of them were lost in the San Francisco fire of 1906. Many of its congeners have since been found on the east branch of Hulen Creek, about 900 feet below the top of the Horsetown group.

This species was proposed as the genotype of "*Coloboceras*" by Crickmay (1927, p. 503–516) but upon what characteristics and for what practical use is not made clear, and it is therefore disregarded as not sufficiently defined for adoption.

Sonneratia crossi Anderson, n. sp.

(Plate 49, figures 4, 5, 6, 7)

Shell small, discoidal, compressed, having a small umbilicus and rounded, nearly smooth sides and ventral border; sides flattened, ornamented chiefly by lines of growth, costate only on and near the umbilical border, upon which appear 20 or more rounded linear nodes, not rising to the middle of the side; only faint costal lines appear on the ventral border, inclining forward; section of whorl narrowly elliptical; suture lines similar to those of *Sonneratia stantoni*, with which it occurs.

The holotype (Calif. Acad. Sci. type Coll.) was found by the writer at the old mining camp of Horsetown, where it was associated with *Puzosia hoffmanni*, *Beudanticeras breweri*, and *Beudanticeras haydeni* Gabb. This is Locality 1344 (Calif. Acad. Sci.) on Clear Creek, Shasta County. Four examples of the species were found here, but it has not been found at any other locality.

The holotype affords the following measurements: greatest diameter, 60 mm.; width of umbilicus, 15 mm.; height of whorl, 23 mm.; thickness of whorl, 17 mm.; umbilical ratio, 0.300:1.

This species is most closely related to *Sonneratia stantoni* Anderson. It is named in honor of Mr. C. M. Cross, whose work with J. A. Taff on the Cretaceous sections in the Diablo Range and in Tehama County has been of great help and value.

Sonneratia rogersi Hall and Ambrose

(Plate 20, figures 6, 7)

Sonneratia rogersi Hall and Ambrose, Nautilus, vol. 30, 1916, p. 69, (not figured); three-quarters of a mile south of Carnegie, Alameda County, California.

The holotype of this species is in the Museum of Paleontology, Stanford University, and has been carefully examined. Its original description shows clearly its relation to the foregoing, to which it conforms in most essential features, except for the number of costae on a single whorl. The surface of the shell is ornamented by about 60 transverse flexuous costae, which usually cross the ventral zone, and terminate at the umbilical border in about one-fourth as many distinct tubercules. This species was compared by the authors to *Sonneratia stantoni* Anderson. It has since been found sparingly on the east branches of Hulen Creek, associated with other species of the genus, and with *Phylloceras theresae*, *Nemodon braweriana*, and *Pholadomya harrigani* Hall and Ambrose. Its horizon is about 900 feet below the top of the Horsetown group, and the Hulen beds, and therefore somewhat lower than the horizon of *Sonneratia stantoni*. The holotype affords the following measurements: greatest diameter, 46 mm.; diameter of umbilicus, 12 mm.; height of whorl, 20 mm.; thickness of whorl, 13 mm.; umbilical ratio, 0.26:1.

Its horizon is regarded as near the middle, or a little below the middle, of the Albian in the Cottonwood district.

Pulchelliidae Douvillé

Pulchellia Douvillé

Pulchellia popenoei Anderson, n. sp.

(Plate 73, figures 1, 2)

The shell of this species is of moderate size, discoidal, moderately inflated, broadly costate; ribs flattened, branching near the middle of the side, strongly flexed, bearing numerous growth lines; ribs terminating at the ventral border in thin, elongated nodes; umbilicus narrow, deep, with steeply sloping walls, flaring above, with rounded borders; siphonal zone narrow, flattened, bordered on either side by moderately elevated costal nodes. Beneath these terminal nodes the ribs are slightly swollen, giving the appearance of a distinct ridge concentric with the periphery. The holotype, septate throughout, has the following dimensions: greatest diameter, 57 mm.; width of umbilicus, 5.5 mm.; height of whorl, 32 mm.; thickness of whorl, 17 mm.; umbilical ratio, 0.096:1.

This example is the first recorded occurrence of *Pulchellia* in the Cretaceous of California, although it is common in the Barremian strata of the northern Andes and has been found in Japan. The species belongs to the group represented by *Pulchellia leai* (Forbes), from which it differs chiefly in the greater curvature of the ribs and in the form of the umbilicus. The holotype was found by W. P. Popenoe and D. W. Scharf on Roaring River, Locality 967, (Calif. Inst. Tech.), a quarter of a mile west of the Millsap road, and beneath the Mitchell zone of the Horsetown group.

Only four identifiable examples have been found; they were associated with

Lytoceras cf. *aulacum* nov. and *Acroteuthis shastensis* nov. The holotype is the property of the California Institute of Technology, Pasadena, California.

Oxytropidoceras Stieler 1920

Genotype *Ammonites roissyanus* d'Orbigny

Oxytropidoceras packardi Anderson, n. sp.

(Plate 50, figure 1)

Shell large, discoidal, inflated near and below the middle of the sides, which converge toward the periphery; keel high and thin; sides heavily costate with about 40 "prorsiradiate" ribs; umbilicus moderately broad, bordered by sloping walls, the slope blending evenly with the convex sides; costae arising at the umbilical suture, inclining forward, crossing the sides in a sigmoid curve, bending strongly forward upon approaching the keel; sides of keel marked by growth lines almost parallel with the periphery; septa numerous, but not well shown.

The holotype is a large fragment making two-thirds of a whorl. It is in the Museum of Paleontology, University of California. It was found by E. L. Packard, of the University of Oregon, about 2 miles south of Ono and near the top of the Horsetown group, where it was associated with *Puzosia hoffmanni* (Gabb) and *Douvilleiceras mammillatum* var. It has the following dimensions: greatest diameter, 176 mm.; width of umbilicus, 47 mm.; height of whorl, 80 mm.; apparent thickness, 45 mm. The species appears to be most closely related to *Oxytropidoceras belknapi* (Marcou), as figured by Adkins (1928, pl. 4, fig. 3), although it possesses fewer and coarser ribs, has a more elevated keel, a gentler umbilical slope, and more strongly curved ribs. It is also closely related to the genotype *Ammonites roissyanus* d'Orbigny.

Three examples of this species, obtained at the type locality by G. D. Hanna and the writer, are now in the Museum of the California Academy of Sciences. Its horizon is near, or above, that of the Neptune zone of the Hulen beds as found on Hulen Creek.

Pervinquieridae Spath

Pervinquieria J. Bohm 1910

Pervinquieria hulenana Anderson, n. sp.

(Plate 52, figure 3)

Species of *Pervinquieria* have long been known in the uppermost Albian beds in the Cottonwood district, but thus far have been confined to the Chico series. The holotype of the present species was found in the Hulen beds below the lowest strata assignable to the Chico series, and beneath the unconformity that marks its base. Its horizon is near the middle of this stage, but within a few hundred feet of the top of the Hulen beds.

The shell is large and broadly umbilicate, strongly costate with a distinctly ovate section in its mature stages; umbilical walls in its younger stages abrupt, rounded and sloping in older shells; in younger whorls the periphery is flattened, but in the older whorls it becomes sloping and ridge-like; keel elevated, wedge-shaped, and prominent; in younger stages of growth (diameter 65 mm.) the section of the whorl is inflated, as broad as high; in older stages (diameter 150 mm.) the section becomes thinner; in youth the ribs on the ventral border are faintly marked by flutings, but with growth these are lost.

The holotype, found by E. L. Packard, is the property of the Oregon State College.

It would have, if complete, a greater diameter of 325 mm.; width of umbilicus, 165 mm.; height of whorl, 85 mm.; thickness of whorl, 60 mm.

The "juvenile" ribs are not known, but those of the older stages become heavy and widely spaced, and each bears a prominent ventro-lateral tubercule, an elongated swelling on the middle of the side, and a similar swelling on the umbilical border; in some cases the ribs divide from bullae, but this seems to be rare, and most of them rise singly. The suture line is not yet well known, but the second lateral lobe is broad, terminating in stout tripartite branches; the second saddle is deeply and narrowly cleft, with rounded terminations. This species appears to belong to the general type of *Pervinquieria trinodosa* (Boese), from the lower Cenomanian of Cerro de Muleros, Mexico.

In the Hulen beds it occurs a little above the horizon of the Neptune zone, and therefore near that of *Oxytropidoceras packardi* nov.

At least two other species of *Pervinquieria* are known from the overlying Chico series, but they differ in section and in other features from the present form. Compared to the number of species of this genus known in Texas "middle Cretaceous," the number appearing in California seems small at best.

Crioceratidae Hyatt 1896

The "family" group Crioceratidae was originally proposed to include certain smaller groups of degenerate, evolute, but often highly ornamented cephalopod forms that seem to have been derived from different older stocks. Besides the genera *Crioceras* Leveille and *Acrioceras* Hyatt, Spath (1924, p. 77, 80) has more recently segregated other groups from the general assemblage under several names, as *Aegocrioceras*, *Pseudocrioceras*, and *Paracrioceras*, and under the family name Hemihoplitidae he has included *Hoplocrioceras* as a new genus. As judged by their forms and other characteristics, most of these genera seem to have had lytoceratid ancestry, although there are others that seem to have descended from hoplitid stocks or from others farther in the background. By his use of the terms Hemihoplitidae and *Hoplocrioceras*, Spath may have intended to suggest their derivation from Hoplitidae, although no clear statement of this view has been found.

Neaverson (1928, p. 390) says only:

"The genus *Hoplocrioceras*, including uncoiled Ammonoids with a characteristic bundling of the ribs at the umbilical tubercule, furnishes a name for the Hoplocrioceratan fauna."

Such arrangements aid only partially in the disposition of the crioceratid forms from the Shasta series of California. If umbilical tubercules and a "bundling of the ribs" at such points are essentials for entrance into this new ammonoid family, there are few California species that could be included in it, even by a generous interpretation of the rule. As far as known at present, only three species show such tubercules, or a bundling on the ribs at these points, but there is good evidence that "*Crioceras*" *remondi* (Gabb) had such tubercules up to a diameter of 60 mm., with a bundling of the costae at these points. These features are lost in later stages of growth, the tubercules being altered to mere swellings on the umbilical border from which costal lines radiate. However, Spath himself (1924, p. 77-80) has included in *Hoplocrioceras* some species that do not show these characters, as far as can be seen in the figures, as for example *Hoplocrioceras laeviusculum* (von Koenen, 1902, pl. 28, figs. 4a, 5).

Another group of crioceratids appears in the middle Horsetown (Barremian) beds. As judged by form, ornamentation, and sutures, this group seems to have come from an hoplitid stock, either from *Neocomites* or from some near ally, but

from none so far known on the Pacific Coast. There is little satisfactory evidence of the adoptability of these forms into any group already mentioned, although possibly they could be included in Hemihoplitidae Spath.

Uhlig (1903, p. 253–255) has illustrated many hoplitid forms from the Valanginian part of the Spiti shales, including some with reduced umbilicus, sinuous divided ribs and peripheral nodes, as for example *Neocomites walkeri* and *Neocomites* aff. *walkeri* Uhlig. Such forms may possibly represent the progenitors of our crioceratid group, and it may be that the parent stocks of these California types should be sought in these distant regions.

However, for the present, the name *Shasticrioceras* may be adopted for these forms. The attention of students who may seek a more suitable name for them is here directed to the neocomitid characters of the species described under this name, especially appearing in their forms, ribbing, and umbilical features, and especially in the resemblance of the suture lines to those of *Neocomites* aff. *walkeri* Uhlig (1903, pl. 87, fig. 4d.).

Crioceras Leveille

Crioceras latum Gabb

(Plate 55, figure 1)

Crioceras latum GABB, Paleont. Calif., vol. 1, 1864, p. 76, pl. 14, fig. 25b; pl. 15, figs. 25, 25a; "near Weaverville, in the Trinity River; vol. 2, 1869, p. 218—STANTON, U. S. Geol. Surv., Bull. 133, p. 17, 18, 83; Elder Creek district.

The holotype of this species is in the Museum of Paleontology, University of California, and has been loaned for study and illustration. Gabb states that it is very closely allied to *Crioceras duvali* Leveille, but as Gabb referred to the description and figure given by d'Orbigny, which Kilian has renamed *Crioceras nolani*, Gabb's statement may be emended accordingly. Gabb stated that the holotype had been obtained in the Trinity River "from a boulder." As Weaverville is not very near any part of the Trinity River, and as no Cretaceous deposits are near the town, the words "near Weaverville" may be interpreted to mean "near Douglas City," where the river does approach such deposits. The "boulder" is a sandy concretion and contains not only the holotype of this species but other identifiable molluscan species, as *Pecten operculiformis* Gabb and a bivalve shell resembling *Nucula gabbi* Stanton. This "boulder" may easily have been carried down from the Lower Cretaceous beds on Redding Creek, where various other Shasta species, including *Pecten operculiformis*, *Pleuromya papyracea*, and various cephalopods, have been found.

Stanton (1895, p. 83) reports the species from the Shasta series south of Elder Creek, in beds here regarded as belonging in the Paskenta group, and also in the "basal Horsetown beds" immediately overlying the Paskenta group.

The several examples referable to this species obtained by the writer were found in the Cottonwood district, as on the North fork of this stream above Ono; at Locality 113 (Calif. Acad. Sci.), 4 miles southwest of Ono; at Locality 1665, Duncan Creek, and in the Paskenta group; at Locality 1353 (Calif. Acad. Sci.), and on Eagle Creek, near Ono, which is in the lowest beds of the Horsetown group. The stratigraphic range of the species is, therefore, nearly that of *Hoplocrioceras remondi* (Gabb)—that is, from upper Valanginian to Hauterivian.

Crioceras duncanense Anderson, n. sp.

(Plate 55, figure 2)

Shell small or moderate in size, as known from the holotype; coiling crioceratid, numerously costate, coils barely touching in young stages, more openly coiling

in older stages; costae of two kinds, major and minor; major costae trituberculate, with one row on each side of the siphonal line, spinose, with slender elevated spines; the two other rows of tubercules low and rounded, lower row transversely elongate; minor costae finer, non-tuberculate, rounded; there are normally five between each pair of major costae; section of whorl broadly elliptical, higher than broad; suture line not shown.

The holotype (Calif. Acad. Sci. type Coll.) was found at Locality 1665 (Calif. Acad. Sci.) on Duncan Creek, a mile above the County road, in a calcareous concretion embedded in sandstone overlying a local conglomerate. It belongs to the group of *Crioceras nolani* Kilian, being somewhat closely related to the form figured by Kilian (1910, pl. 4, figs. 3a, 3b) under this new name.

This specimen was found with the preceding species and with *Neocomites russelli* nov., *Lytoceras* cf. *traski* nov., *Pleuromya papyracea* Gabb, and various other forms. A fragmentary but good specimen of *Spiticeras*, closely related to *Spiticeras ducale* (Matheron), was obtained from a block of limestone lodged in the conglomerate beneath the sandstone.

Crioceras duncanense is doubtless related to *Crioceras latum* Gabb but differs from it in the relative width of coil, the whorls being less widely separated and the minor costae being more numerous. Both forms occur at this locality.

Hemihoplitidae Spath 1924

Hoplocrioceras remondi (Gabb)

(Plate 62, figures 1, 2, 3, 4, 5; plate 63, figures 1, 2)

Crioceras (? *Ancyloceras*) *Remondi* Gabb, Paleont. Calif., vol. 1, 1864, p. 75, pl. 14, figs. 24, 24a; North fork of Cottonwood Creek, Shasta County, (not *Ancyloceras* sp. indet. pl. 15, fig. 30).

Ancyloceras Remondi Gabb (in part), Paleont. Calif., vol. 2, 1869, p. 138, pl. 23, fig. 17.

This species appears to have been much misinterpreted not only by later writers, but by Gabb himself; other species, and even genera, have been included under the name. The lectotype (probably the holotype) was taken by Gabb to the Academy of Natural Sciences of Philadelphia where it still remains. It was loaned to the California Academy for examination and illustration. It bears no distinctive label but is contained in a tray with other specimens labelled "*Ancyloceras Remondi*." Some of these specimens do not belong to this species. The locality of discovery is not definitely given, but the matrix and associated species in it indicate a locality near Ono, probably in the Ono zone near the base of the Horsetown group, where they have all been found.

The species seems to belong to the group of *Crioceras laeviusculum* von Koenen, which Spath (1924, p. 73) includes in his genus *Hoplocrioceras*.

The holotype is not well illustrated by Gabb's (1864, pl. 14, fig. 24) drawing, but the characters of the species are better shown in the photographic illustrations here given. The costae are fascicled on the dorsal border, arising from elongated bullae in its younger stages, which disappear with the growth of the shell.

According to Gabb, the

"ribs are often dichotomous, and occasionally, though rarely, anastomose near the dorsum (venter). In one case, remains of a few dorsal spines were observed."

This reference to "dorsal spines" should be understood to refer to tubercules on the ventro-lateral angles, not true spines.

These tubercules are indicated in his figure and are seen on the lectotype. They disappear when the shell attains a diameter of 60 mm. or less. In section the whorls are narrowly elliptical, the sides rounding abruptly on the dorsal border, but sloping

more gradually to the ventral border. A single constriction appears at a diameter of 70 mm. on the last whorl of the lectotype, which is septate throughout, but this is not found on all examples. The largest example found has a total length of 10 inches, more than half of which is formed by the somewhat straightened arm, or body chamber.

This species has been found on the Cottonwood Creek (Locality 1353, Calif. Acad. Sci.), and in the same zone on Eagle Creek, near Ono, where it was associated with *Acroteuthis kernensis* nov., *Neocraspedites aquila* nov., *Shasticrioceras poniente*, and *Inoceramus colonicus* nov., all of which are found in the lowest beds of the Horsetown group in the Cottonwood district. *Hoplocrioceras remondi* has also been found in the middle part of the Horsetown group in this district, in beds believed to be below the middle of the Paskenta group, as at Locality 1665 (Calif. Acad. Sci.) on Duncan Creek, at Silvester's ranch on the Middle fork of Cottonwood Creek, and on Dry Creek, at about the same stratigraphic horizon. Its stratigraphic range in this district is from the lower or middle Paskenta group (Valanginian) to the middle of the Horsetown group (Bedoulian). In the McCarthy Creek district, as recorded by Stanton, its range may be somewhat more restricted, but it has been found in both Paskenta and Horsetown beds.

Hoplocrioceras onoense Anderson, n. sp.

(Plate 53, figures 3, 3a, 3b; plate 61, figure 4)

In the collection of the Academy of Natural Sciences of Philadelphia there is a fragment of *Hoplocrioceras*, related to *H. remondi* (Gabb), but possessing much finer flexuous costae, which are bundled on the dorsal border and have a section relatively much broader. It is No. 12883 (Phila. Acad. Nat. Sci.), and although it has no locality label the lithology, preservation, and association with other forms under the same number indicate that it was found in the Ono zone, either on Eagle Creek or on the Cottonwood Creek, near Locality 1353 (Calif. Acad. Sci.). The suture line is similar to that of *H. remondi* (Gabb). It bears the same number as a small example of *Crioceras latum* and also of *Hoplocrioceras remondi* from the same place. The holotype has the following dimensions: length, 45 mm.; height, 22 mm.; width of whorl, 18 mm. As seen on the periphery there are about 9 linear ribs to the centimeter. These are slightly flexuous and nearly normal to the curvature of the periphery. The suture lines are trifid, possessing long slender elements. No other example of this species has yet been seen.

Hoplocrioceras wintunium Anderson, n. sp.

(Plate 60, figures 3, 4)

Shell not large, coiling is first crioceratid, but later more openly, the whorl of the body chamber departing from the earlier coil and forming a short curved shaft, apparently not forming a hook; early coils not quite contiguous and gradually spreading; section of the whorls sub-quadrate, narrowing toward the rounded periphery; shell slightly excavated on the dorsal zone; costae beginning in a backward sinus on the dorsal zone, curving upward in crossing the umbilical border, slightly flexed on the side of the shell, somewhat swollen and often dividing on the dorsal border, or a little below the middle of the side on the septate portion of the shell; costae on the younger whorl nearly equal, but on the body chamber often showing intermediary ribs on the upper part of the side; all costae crossing the ventral zone without interruption, but slightly flattened; sutural characters not well shown, but the septum beginning with a siphonal saddle somewhat rectangular in

form, and having a tripartite first lateral lobe, in which the finer elements terminate in sharp digitoid points.

This species belongs to the group of *Hoplocrioceras laeviusculum* (von Koenen). The holotype (Calif. Acad. Sci. type Coll.) was obtained at Locality 1661 (Calif. Acad. Sci.), a mile west of the Murphy house in the Roaring River district, where it was associated with *Pseudocrioceras indopacificum* nov., *Shasticrioceras poniente* nov., and *Inoceramus ovaloides* nov.

The holotype is much broken but permits of restoration, and its general form is shown in the drawing, which is made from careful measurements.

Hoplocrioceras yollabollium Anderson, n. sp.

(Plate 72, figure 2)

Because of the apparent "bundling" of the ribs at the umbilical border, this species is placed here with some doubt as to its proper lineage. The shell is large, discoidal, apparently compressed, having a crioceratid coil and strong, somewhat "rursiradiate" primary ribs, between which the interspaces are relatively broad; interspaces occupied by two to four fine secondary costae, which merge with the primary ribs near the umbilical border; sides slightly flattened, section of whorl higher than broad; whorls not contiguous, but apparently not leaving a regular spiral. The holotype is a rock mold, represented by the plastotype (Calif. Acad. Sci. type Coll.), shown in the figure. It was found by A. I. Gregersen, on Browns Creek, 1½ miles southwest of the Clements ranch in eastern Trinity County. Its stratigraphic position is apparently about 600 feet beneath the zone exposed at Clements ranch, and probably not far from the horizon of *Crioceras latum* Gabb. It is thought to represent an upper Paskenta horizon, not far from that of the Hamlin-Broad zone, Locality 113 (Calif. Acad. Sci.), southwest of Ono, Shasta County.

In its ribbing and form this species has some resemblance to *Crioceras bederi* Gerth, though less to *Crioceras andinum* Gerth, from the Lower Cretaceous of the Rio Diamante, Argentina.

Shasticrioceras Anderson, n. gen.

In the group of crioceratid forms for which this name is proposed hoplitid characters are more prominent than in other related groups found in the Shasta series in California. These characters seem to reflect *Neocomites* more nearly than any of the other hoplitid groups, although no close relationship is apparent. Characteristics of the genus are seen in its form, ribbing, ornamentation, manner of uncoiling, and, with growth, its progressive changes in form and ornamentation. In its earlier stages the coils are closely approximate but they soon become separated, and finally the shell sends off a long, curved arm (body-chamber), although without developing a recurved limb. In none of the several species of this group so far found have any traces of dorsal (umbilical) tubercules been observed, even in young stages of growth, having a diameter of 25 mm. or less. In all cases the costae begin in a short forward flexure on the dorsal border, cross the sides in an openly sigmoid curve, and on the ventral borders develop rounded tubercules, which in adult stages become the most notable feature of the shell. The sides are flattened, or but little convex, the section of the whorl is subquadrate, the thickest part being a little above the dorsal margin, from which zone the sides converge toward the periphery. The costae are at first fine and crowded but with growth become heavier and more widely separated; in young stages these often divide, though no such tendency is seen later; all costae (or ribs) cross the ventral zone without interruption, although on the venter they may be somewhat

flattened. The suture line is well developed and clearly is hoplitid in character, strongly resembling that of *Neocomites*. The small siphonal saddle is high and narrow, and all the saddles are deeply cleft; the first lateral lobe with a broad stem has three main branches, showing asymmetry, and terminating in long, narrow, digitoid points.

Shasticrioceras poniente Anderson, n. sp.

(Plate 57, figures 1-3; Plate 67, figures 4, 5)

Shell large, discoidal, coiling crioceratid; coils closely approximate in young stages, becoming more separated with growth, the final body chamber departing widely from the coil, forming a long straightened arm; section of whorls subquadrate, flattened on the sides in young stages, becoming more inflated in older shells; sides numerously costate in youth with fine, mostly simple, sometimes divided costae, which at first are slightly sigmoid, but become heavier and straighter in old age; costae closely spaced in youth, becoming progressively more widely spaced in later whorls; costae (or ribs) tuberculate only on the angulated ventral border, with tubercules slightly elongated laterally, sometimes prominent; all ribs crossing the ventral zone without interruption, but weakened on the periphery; ventral zone flattened with respect to ribs, rounded with respect to interspaces.

A single detached large fragment found with the holotype measures nearly 18 inches in length, has widely separated ribs which are rounded and swollen on the dorsal border, roundly tuberculate on the ventral border, and slightly inflated between. The holotype (Calif. Acad. Sci. type Coll.) was found at Locality 1657 (Calif. Acad. Sci.), a mile east of the Jordan house near Mitchell Creek, in the Mitchell zone, associated with *Pseudocrioceras* sp., *Ptychoceras natrice* nov., and *Acroteuthis shastensis* nov. Other species of this genus have been found in or near the same zone not far distant. Whiteaves has figured a similar form from the Cumshewa Inlet, Queen Charlotte Islands, under the name "*Ancyloceras*" *remondi* Gabb, but its relationship seems to be nearer to *Shasticrioceras poniente* than to *Hoplocrioceras remondi* (Gabb). This is the most widely distributed crioceratid species found in the Cottonwood district in California.

Shasticrioceras hesperum Anderson, n. sp.

(Plate 56, figures 1, 2; Plate 68, figure 3)

Shell large, form similar to the preceding species but more finely sculptured; young whorls in contact, more separated in older stages, and finally forming a straightened arm, or body-chamber; whorls quadrate in section with distinctly flattened sides, the ratio of height to width of whorl being about 24 to 17; sides closely costate in young stages of growth, but with age the costae (or ribs) become thicker, straighter, and more distant; ribs tuberculate only on the ventro-lateral angle, each rib bearing a small, slightly oblique, spineless node; although weakened in the ventral zone all ribs cross it without interruption; ventral zone flattened. The holotype (Calif. Acad. Sci. type Coll.) was found near Locality 1661 (Calif. Acad. Sci.) but in strata about 200 feet higher in the section than the strata exposed here. It occurs with the preceding species, and also above it, and a little below the horizon of *Ancyloceras ajax* nov., and within the Mitchell zone. The holotype has about 108 peripheral costae to the whorl in adult stages of growth, most of which arise singly on the dorsal wall, cross the side, on which they occasionally branch, and occasionally produce short intermediary ribs, all of which bear tubercules on the ventral border. The holotype, with the outer whorl somewhat displaced, measures 175 mm. in diameter. In form, costation, and sutural characters it suggests hoplitid, perhaps a neocomitid, ancestry, and for this reason is considered with the preceding

as referable to the family of Hemihoplitidae Spath, although it shows no tendency toward a bundling of the ribs on the dorsal border, as is found in *Hoplocrioceras remondi* (Gabb).

Shasticrioceras whitneyi Anderson, n. sp.

(Plate 55, figure 1)

Shell of moderate size, coiling at first crioceratid, whorls apparently not contiguous; with growth, leaving the early coil and forming a broadly curved limb in one plane; section of whorl narrowly quadrate, twice as high as broad; sides sloping gently toward the periphery, more abruptly toward the dorsum; sides costate, having mostly simple, sometimes branching, rounded, slightly flexuous ribs without pronounced tubercules; having only small rounded swellings on the ventral border; ribs arising on the dorsal side in a small forward sinus; sides crossed by a few broad grooves between which there are about eight intervening costae; ventral zone narrowly rounded or slightly depressed along the siphonal line; sides a little convex; septa not well exposed, but the first lateral lobe is asymmetrically tripartite, saddles deeply cleft. This species is undoubtedly congeneric with *Shasticrioceras hesperum* but is smaller and has a more open coil, more compressed section, and simpler, more rounded costae. The holotype (Calif. Acad. Sci. type Coll.) was found at Locality 1653 (Calif. Acad. Sci.) near Mitchell Creek, half a mile northwest of Barr's corral, by G. D. Hanna. Its horizon is near that of Locality 1661 (Calif. Acad. Sci.) and a few hundred feet beneath the Mitchell zone containing its congener, *S. hesperum*.

Of the species here described under this genus the present one has the more open coil in its younger stages. An example, less than an inch in diameter, possesses fine tubercules on the ventral border and has somewhat more flexuous ribs than those of the holotype.

Shasticrioceras inflatum Anderson, n. sp.

(Plate 56, figures 3, 4; plate 58, figure 4)

Various fragmentary specimens, representing a distinct form of this genus, found in or near the Mitchell zone, have a broader and more rounded section than any of the preceding forms. The fragment selected for the holotype consists of a quarter of a complete whorl, septate throughout and having the following dimensions: total length, 118 mm.; measured on the periphery, 135 mm.; maximum height, 48 mm.; maximum thickness, 33 mm.; section of whorl semi-elliptical, the greatest width being at about one-third the height above the dorsum; about 20 ribs on the holotype, low, rounded, and scarcely flexuous; only a few are divided on the outer one-third of the side. The ventral zone is a little flattened, but not culcate; ribs only faintly tuberculate on the ventral border. The species is probably more closely related to *S. poniente* nov. than to any of the other forms described but it is relatively broader and is not flattened on the sides or on the dorsum. The holotype (Calif. Acad. Sci. type Coll.) was found in the Mitchell zone at Locality 1347 (Calif. Acad. Sci.), 6 miles south of Ono, Shasta County.

Pseudocrioceras Spath 1924

Genotype, *"Crioceras" abichi* (Bacevic and Simonovic) in Anthula, Beitr. zu Pal., Geol. Oest. Ungarns, vol. 12, 1899, p. 124, pl. 12

Spath has proposed this generic name for ammonoids of the group of *"Crioceras" abichi*, giving no further characterization. If one may judge from the figure and description given by Anthula, the shell is large or massive, closely coiled in its younger stages, having a somewhat elliptical or subquadrate section; heavily costate

with two kinds of ribs, of which each third, fourth, or fifth rib is tuberculate, with rounded mammillary tubercules in three rows on either side of the siphonal plane; the intervening ribs are simple and without tubercules; the coiling is crioceratid in its early stages but later departs from this manner and forms a partly straightened shaft (cyrtocone) on which the ribs become coarser. The ribs have an ancyloceratid aspect which, according to Anthula, recalls *Ancyloceras urbani* Neumayr and Uhlig. At least two species of this genus seem to have been found in the Lower Cretaceous (Barremian) of California, but, for lack of sufficient characterization perhaps, this cannot be stated with entire confidence.

Pseudocrioceras stentor Anderson, n. sp.

(Plate 61, figures 1, 1A)

Shell large, robust, coiling openly crioceratid, coils not contiguous; section of whorl circular, slightly flattened on the dorsum, closely costate; ribs of two classes, major and minor; major ribs arising as broad, transverse, trituberculate ridges, between which are six to eight slightly sinuous costae extending around the whorl almost at right angles to its axis, but with a slight deviation, or sinus, in the dorsal zone; sutures not well shown. The holotype (Calif. Acad. Sci. type Coll.) was found at Locality 1861 (Calif. Acad. Sci.), a mile west of the Murphy house in the Roaring River district, 7 miles south of Ono, Shasta County. It has the following dimensions: length of cone along the siphonal zone, 250 mm.; transverse diameter at larger end, 55 mm.; tapering to a diameter of 27 mm. This species was found associated with *Hoplocrioceras wintunium*, *Shasticrioceras poniente*, *Acrotauthis kernensis*, and *Inoceramus ovatoides* nov. The species bears some resemblance to *Australiceras irregulare* (Tenison-Woods) as illustrated by Whitehouse, although the similarity is probably in form only. The horizon is believed to be upper Barremian, and it can hardly be younger.

Acrioceras Hyatt 1896

Acrioceras voyanum Anderson, n. sp.

(Plate 59, figure 1)

Shell of medium size, coiling at first crioceratid, but later forming a shaft and body-chamber having a recurved limb; section of early whorls nearly circular, becoming gradually compressed on the sides, particularly on the shaft and body-chamber; surface marked by major and minor costae; major costae trituberculate, the tubercules on the ventral border being spinose in early stages, but depressed in later stages of growth; minor costae simple, normally three or four intervening between pairs of major costae; costation on the shaft oblique, without spines; on the later part of the shaft all costae tending to become equal and smooth, only a few showing tubercules; three or four constrictions appear on the holotype near the top of the crosier. The holotype of this species is in the Museum of Paleontology, University of California (No. 110) and was a part of the Voy collection. It is said to have been found on Cottonwood Creek, Shasta County, but more definite indication of its position was not given. It is partly encased in a hard calcareous concretion, such as abounds in the lower part of the Horsetown group, and seems to have come from a zone somewhat above the base of the group. The species belongs to the group represented by the genotype, "*Ancyloceras*" *tabarelli* (Astier), as illustrated by Sarasin and Schoendelmayer, differing from it chiefly in the thickness of the shaft and in the number of minor costae. The concretion containing the holotype contains also remnants of carbonized wood, in which there are various fragments of a wood-boring shell, possibly that of *Turnus plenus* Gabb.

Acrioceras starrkingi Anderson, n. sp.

(Plate 59, figures 4, 4A; plate 65, figure 4A)

Shell of medium size, early whorls not known; shell forming a shaft and bent body-chamber, with an enlarged recurved limb; shaft closely costate, with small simple costae arising in the dorsal zone at its median line, curving at first strongly forward to the dorsal border, thence rising with a gentle forward slope toward the ventral zone; costae prominently tuberculate on the ventral border only, where two, three, or four lateral costae are gathered into knot-like, rounded tubercules; ventral zone depressed, with costae crossing it somewhat irregularly, either singly, in pairs, or in trios. On the body-chamber the ribs become greatly altered, forming coarse ridges, which are tuberculate chiefly on the dorsal border; ribs a little prominent, often dividing at the dorso-lateral node, separated by interspaces wider than the ribs; from some of the dorso-lateral nodes the ribs branch into pairs, from others they arise singly, all crossing the ventral zone without interruption; above the dorsal border are two rows of inconspicuous tubercules on most of the ribs, one above and another below the median line of the side, and a single row on the ventral border, tending to produce an angle on the rib; section of both limbs subcircular, flattened on the dorsal zone, narrowed slightly toward the ventral zone. This species appears to belong to the group of *Acrioceras silesiacum* (Uhlig) from the Wernsdorfer beds; *A. silesiacum* seems to be its nearest analogue. The holotype (Calif. Acad. Sci. type Coll.) was obtained at Locality 1661 (Calif. Acad. Sci.), a mile west of the Murphy house in the Roaring River district. It was found with *Shasticrioceras poniente*, *Pseudocrioceras stentor*, *Acroteuthis shastensis*, and *Inoceramus ovaloides* nov. Its horizon is probably lower Barremian, somewhat below that of the Mitchell zone.

Aspinoceras n. gen.

Genotype, *Aspinoceras hamlini*, n. sp.

Among the ammonoid forms found in the Hamlin-Broad zone (upper Valanginian) in the Cottonwood district there is an unusual crioceratid type for which no suitable generic name has been found, although the type itself is not unknown. Its perisphinctoid (? aulacosphinctoid) character seems to appear in its general form, subquadrate section of whorl, and manner of costation—that is, in the alternation of simple and divided ribs. As far as can be seen in the holotype-genotype there is no evidence of costal spines or tubercules at any stage of its development, and in this simplicity of ornamentation, as well as in its manner of coiling, it recalls "*Crioceras* (*Ancyloceras*)" *dilatatum* d'Orbigny, from the Neocomian of France. To this group probably belongs "*Crioceras*" *mulsante* Astier, as figured by Sarasin and Schoendelmayer (1902, p. 138, pl. 18, figs. 1, 2), who have compared it also with "*Crioceras*" *dilatatum* d'Orbigny. Neither d'Orbigny, Astier, nor later authors have described any costal ornamentation for these species, and, as far as can be seen in their figures, none exists at any stage of growth. No description or figure has been found illustrating the suture line of either of them, and this feature is poorly shown in the proposed genotype. The only sutural elements exposed are a stout first lateral lobe which has asymmetrical, tripartite divisions and an asymmetrical, deeply cleft second saddle. These add little to the characterization of the genus, although they conform to a perisphinctoid type of ancestry.

Aspinoceras hamlini Anderson, n. sp.

(Plate 60, figures 1, 2)

Shell of medium size, moderately inflated, coiling at first crioceratid, later forming a short, gently curved shaft and a retroversal bucal limb; section of early whorls nearly circular, becoming semi-elliptical on the shaft, higher than broad; dorsal

zone flattened; shell costate throughout, having the costae somewhat reduced on the dorsal side of the shaft, stronger on the ventral border, especially on the body-chamber; costae rounded, separated by narrow, rounded interspaces; on the smaller coil the costae are narrow and the interspaces broader; costae not showing spines or tubercules on any part of the shell, including its earlier coils; costae often dividing near the dorsal border and on the upper part of the side; two constrictions visible, crossing the sides and ventral zone near the crosier, deep and narrow. The holotype (Calif. Acad. Sci. type Coll.) was found by E. J. Broad in the Hamlin-Broad zone at Locality 113 (Calif. Acad. Sci.), 4 miles southwest of Ono, Shasta County, and was donated by him to the California Academy of Sciences. The horizon of discovery is about 500 feet beneath the lowest beds of the Horsetown group. It was associated with *Polyptychites shastensis* nov., *Lytoceras aulacum* nov., *Acroteuthis shastensis*, and other upper Valanginian species. The holotype has the following dimensions: length (incomplete), 85 mm.; maximum height of whorl, 30 mm.; maximum thickness, 27.5 mm.; sutures known only in part, including a stout first lateral lobe having asymmetrical, tripartite divisions, and an asymmetrical, deeply cleft second saddle, the secondary lobe being tripartite, terminating in acuminate points. The species appears to belong to the group of *"Crioceras" dilatatum* d'Orbigny, from the Neocomian of France.

Ancyloceratidae Hyatt, emend. Whitehouse

Hyatt included in this family many Lower Cretaceous trituberculate genera, not only belonging to the type of *Ancyloceras matheronianum* d'Orbigny and *A. renauxianum* d'Orbigny, but also other widely divergent forms. According to Whitehouse (1926, p. 207–217), "Even if restricted to the trituberculate genera, the family is certainly heterogeneous." However, with *Ancyloceras* (s. s.), which is trituberculate, he includes in the family other genera which are non-tuberculate, and which do not coil in the manner of *Ancyloceras*. He states that the immediate ancestor of *Ancyloceras* is unknown but suggests a succession of genera which may possibly belong in this lineage, including *Australiceras*, which is trituberculate in its early stages, *Tropaeum* (Sowerby) Hyatt, which is non-tuberculate, and *Ammonitoceras*, which is bituberculate. These are found in the Aptian (Bedoulian and lower Gargasian), occurring in the order in which they are here named, insofar as they occur, or are known in eastern Australia. In the Lower Cretaceous of California the sequence is the same, but it seems to begin with *Ancyloceras* in the Barremian, and as far as known it closes without any known species of *Ammonitoceras*. In later Gargasian time the smaller forms, here included in *Hamiticeras* (n. gen.), make their appearance, but any relationship to *Ancyloceras* has yet to be determined, although they are included in this family.

To the genera included by Whitehouse in the family the writer has added *Shastoceras*, n. gen., and *Hamiticeras* nov., and it may later appear that some genera here assigned to Crioceratidae would be better placed in Ancyloceratidae.

Ancyloceras d'Orbigny

Genotype, *Ancyloceras matheronianum* d'Orbigny

In the Lower Cretaceous of California there are many ammonoid forms referable to *Ancyloceras* (s. s.), most of them occurring in upper Barremian and lower Aptian strata. No ancestral forms are known in earlier beds of the Shasta series, or in fact in any West Coast Mesozoic deposits, and, although species of *Lytoceras* and *Crioceras* are well known in the Paskenta group (Valanginian), the ancestry of *Ancyloceras* is not at all clear. The genus appears rather suddenly in the stratigraphic section, seems to have lived only a short life in the Great Valley embayments, and to have disappeared as suddenly as it came. It is not evident that its several species left any

descendants, although certain smaller forms included in this family appear in later Aptian time, including two or more species of *Hamiticeras* n. gen.

Little has been found in the literature bearing upon the life history or habits of *Ancyloceras* species. Judging from their protective armament, especially about the body-chamber, it may be inferred that in this basin they had powerful adversaries and that these may have been the cause of their short career in these waters. Most of the shells found here bear evidence of battle and of death from injury, especially evident in the crushing of the shaft or septate part of the cone. In many cases the shaft is crushed immediately beneath the body-chamber, leaving other parts still entire. Possibly such injuries were inflicted by other cephalopod forms having no shell. That at least some species of *Ancyloceras* were carnivorous, preying upon weaker members of their class, is indicated in an example of *Ancyloceras attrox* nov., the lower part of whose body-chamber was found, showing clearly that immediately above the last septum, in the space presumably occupied by the stomach of the animal, the shell was filled with fragmented shells of other smaller species of cephalopods. In one example of *Tropaeum percostatum* a number of small belemnoids were found at the aperture, in such position as to indicate that they had been taken by it Similar facts were observed in an example of *Lytoceras aulacum*, wherein belemnoids and other small molluscan species were found similarly situated.

Ancyloceras elephas Anderson, n. sp.

(Plate 84, figures 1, 2; plate 88, figure 1

Shell large, robust, coiling ancyloceratid, closely costate, costae changing with growth; earlier coils trituberculate; shaft with close-set nearly straight, rounded ribs encircling it, at first normal to the dorsal border; later becoming oblique, especially on the body-chamber; each fifth or sixth rib trituberculate; the tubercules on the younger whorls small, mammillary; on the older part at first low and tumid, confined to the two inner (dorsal) rows, and on the body chamber becoming prominent and spinose in three outer rows; body-chamber broadly inflated, especially below the bend, but near the aperture the section becomes narrowed to a slot-like opening about one-fourth the width of the body-chamber; recurved portion of the shell bearing thick and nearly straight ribs, surmounted by broad, strong spines; section of recurved limb quadrate, higher than broad. The species belongs to the group of *A. renauxianum* d'Orbigny, having a similar form and protective equipment. The major ribs and spines develop from the point where septation ends and increase in strength and prominence with the further growth of the body chamber. The holotype (Calif. Acad. Sci. type Coll.) was found in the Mitchell zone, near Roaring River, 6 miles south of Ono, Shasta County, associated with *Shasticrioceras poniente*, *Inoceramus ovatoides*, and other cephalopods. The holotype has the following dimensions, total length, 16 inches; the shaft, somewhat elliptical in section, increases in greater diameter from 2.5 to 4.5 inches near the last septum, where the greater axis changes from a dorso-ventral to a transverse direction. The greatest width of the shell is near the middle of the body-chamber, where the transverse width is nearly 5 inches. The horizon of this species is thought to be near the upper limit of the Barremian. The shaft of the holotype is crushed beneath the body-chamber. Only fragments of other examples of the species have been found.

Ancyloceras attrox Anderson, n. sp.

(Plate 89, figures 1, 2, 3, 3a)

Shell large, robust, coiling ancyloceratid, heavily costate, trituberculate, having major and minor ribs; major ribs tuberculate, with one or two minor unadorned ribs intervening between them; ornamentation of shaft and younger coiled portions

not known; tubercules on body-chamber at first low and rounded, becoming stronger and more prominent above; heaviest ribs and tubercules near the top of the crosier; ventral zone relatively narrow, bordered on each side by rounded tubercules on the shaft and lower part of the body-chamber; section of shaft sub-elliptical, higher than broad, but becoming in the body-chamber transversely expanded, broader than high; bend of crosier abrupt; sutures not shown. The holotype (Calif. Acad. Sci. type Coll.) was found in the Mitchell zone, a mile north of Barr's corral on Mitchell Creek, accompanied by *Parahoplitoides cerrosensis* nov. in strata that may be referred to a lower Aptian horizon. As far as known this is the latest species of *Ancyloceras* found in the Cottonwood district. A large fragment of this species including the body-chamber showing the last septum was found near the holotype; the body-chamber near this septum was compactly filled with fragments of smaller shells, including smaller cephalopods.

Ancyloceras ajax Anderson, n. sp.

(Plate 65, figures 1, 2, 3)

Shell large, robust, coiling ancyloceratid, closely costate, costae changing with growth of the shell; earliest coils unknown, shaft increasing regularly in diameter up to the position of the last septum; costae at first nearly straight, simple, and normal to the dorsal border, becoming gradually oblique, and at the same time more distinct, and on the body-chamber developing tubercules on each fifth or sixth rib, as in *A. elephas*, to which it is nearly related; tubercules at first small, elongated in the direction of the rib; later tubercules becoming stronger, those at the top of the crosier being heavier, but most developed on the reverse limb; aperture unknown; body-chamber inflated transversely, but less so than in either *A. altrox* or *A. elephas*; shaft expanding less uniformly than in *A. altrox*, the transition from shaft to body-chamber being more abrupt; greatest diameter of the body-chamber is near the top of the crosier and transverse to median plane; section of the shaft always higher than broad; on the body-chamber the reverse is true.

The holotype (Calif. Acad. Sci. type Coll.) was found at the top of the Mitchell zone, south of Roaring River, stratigraphically about 200 feet above the horizon of Locality 1661 (Calif. Acad. Sci.); its horizon is thought to be near the boundary of Barremian and Aptian strata. In this specimen the shaft is crushed immediately below the body-chamber as if from an injury while living, the sides being broken longitudinally by overthrust of the shell, as by compression. All parts of the shell were found in place in the position shown in the figure.

Ancyloceras durrelli Anderson, n. sp.

(Plate 57, figures 1, 2; plate 58, figure 1)

Shell large, robust, coiling ancyloceratid, closely costate in early coil and on the shaft; costae non-tuberculate on the shaft, trituberculate on the earlier coil and on the body-chamber; section of shaft nearly circular; section of body-chamber becoming sub-elliptical; ribs on body-chamber becoming suddenly thick and broad, bearing low, tumid tubercules; ribs on bucal limb narrow and elevated, but strong. In its manner of costation and ornamentation, this species is intermediate between *Ancyloceras*, of the type of *A. ajax*, and *Shastoceras* (gen. nov.), the latter possessing no tubercules except on the earliest coils, which are weakly tuberculate on the ventral border. The holotype (Calif. Acad. Sci. type Coll.) consists of the larger part of the shaft, gently curved, bearing slightly oblique, and nearly straight, rounded costae, which occasionally divide above the dorsal border. The suture line consists of long, tripartite, and branching lobes and broad, deeply cleft saddles, showing hoplitid (or possibly perisphinctoid) characters. The paratype (Calif. Acad. Sci. type Coll.)

consists of a body-chamber, not known to belong to the same individual, although to one of the same size. The holotype, paratype, and smaller fragments of other individuals were found at Locality 1661 (Calif. Acad. Sci.) in beds near the bottom of the Mitchell zone in the lower part of the Horsetown group, a mile west of the Murphy house south of Roaring River. The holotype has the following dimensions: length along siphonal line, 230 mm.; diameter of shaft at top, 60 mm.

Australiceras Whitehouse 1926

Genotype, *"Crioceras" jacki* Etheridge Jr.

According to its author, "the genus is proposed for a group of species richly represented in the Australian Aptian," and it is known also in other countries. He gives the following diagnostic notes (Whitehouse, 1926, p. 213):

"Crioceratid shells with initial whorls trituberculate, later whorls without tubercules until the adult body-chamber, which is trituberculate; costae simple or bifurcating near the umbilical margin; septal suture (I. U. L. E.) with prominently bifid, relatively short-stemmed saddles and regularly trifid lobes."

No less than six species of this genus are described by Whitehouse from the Aptian of Australia. The number of species found in corresponding horizons in California is less, although it appears that at least two exist, and there are indications of still others in fragmentary examples.

Australiceras argus Anderson, n. sp.

(Plate 70, figures 1, 1a, 1b, 2)

Shell rather large, robust, subcircular in section of whorl, coiling crioceratid, heavily costate; ribs nearly straight, or curving forward in mature examples (5 to 6 inches in diameter); in young stages below 76 mm. costae alternately simple and trituberculate, the latter being much heavier; at a diameter of 85 to 90 mm. the costae all become simple and rounded, without tubercules, except an occasional one near the ventral border; costae cross the ventral zone with a forward sinus, and the flattened dorsal area with a backward bend; shell septate up to a diameter of 6.5 inches, not known beyond this point; septa not well exposed. In its mode of coiling, costation, and other characters, this shell bears some resemblance to *Australiceras robustum* Whitehouse (not von Koenen), from the upper Bedoulian of central Queensland, Australia. However, there are obvious differences, as in the single minor ribs in the present species, instead of two or more, in its less prominent outer tubercules, in its forward curving ribs, and in its relatively higher section. The holotype (Calif. Acad. Sci. type Coll.) was found on Bee Creek, 4 miles south of Ono, Shasta County, on the Shoup ranch, and stratigraphically a little below the Argonaut zone containing *Tropaeum percostatum* (Gabb), *Phylloceras onoense* Stanton, and *Parahoplitoides shoupi* nov. A larger example, somewhat distorted by rock pressure, was found in the same zone 1½ miles farther south. Fragments of this, and perhaps other species of the genus, have been found at other places in the Bald Hills of the Roaring River district south of Ono, but not sufficiently complete for description.

Tropaeum J. de C. Sowerby, 1837

Genotype, *"Crioceratites" bowerbanki* Sowerby

The genus *Tropaeum* of Sowerby was revived by Hyatt (1900, p. 571). According to Whitehouse (1926, p. 213):

"the genus was derived from *Australiceras*, with which it is identical in coiling, costation and septal sutures, but it appears to have developed along several lines."

Tropaeum, as represented by its genotype, is non-tuberculate, while most if not all

species of *Australiceras* bear tubercules, at least in their younger stages. Whitehouse believed that *Tropaeum* was achieved by the abrupt cessation of tuberculation. The number of species of this genus occurring in the Lower Cretaceous of California is not known, but fragmentary examples of the genus indicate more than one. Examples are not rare in the Argonaut zone and appear in strata just above it, but in all cases they are found in either Barremian or Aptian strata. The range appears to be from upper Barremian to lower Gargasian. Examples of the genus have been found in the Lower Cretaceous of the Alaskan coast, near Cook Inlet.

Tropaeum percostatum (Gabb)

(Plate 71, figure 1; plate 72, figure 1)

Crioceras percostatus GABB, Paleont. Calif., vol. 1, 1864, p. 77, pl. 16, fig. 26; pl. 17, fig. 26a; North fork of Cottonwood Creek, Shasta County (not "*Ancyloceras percostatus*" Gabb, vol. 2, 1869, p. 138, pl. 24, fig. 19, Voy collection).

Gabb's (1864, p. 77, pls. 16, 17) original figures and description of this species afford a fair conception of its form and other characters, although they are not at all complete. His account (Gabb, 1869, p. 138a, pl. 24) included under this name a quite distinct species and genus. As no later figures and description of either form have appeared, the earlier figures of "*Crioceras*" *percostatus* are selected as representing Gabb's species. The second form included by him is described herein as *Shastoceras behemoth* n. sp. The present species *Tropaeum percostatum* (Gabb) is not uncommon in the Horsetown group in the Cottonwood district and has been found as far south as Hayward, Alameda County. Good examples have been found on Hulen Creek, Cottonwood Creek, Alderson Creek, Bee Creek, Mitchell Creek, Roaring River, and McCarthy Creek, in all cases in nearly the same horizon. In its general features it is not unlike *T. bowerbanki* (Sowerby). In form, costation, and suture lines in its younger stages of development, it resembles *Australiceras*, as suggested by Whitehouse, although it lacks the tuberculate ribs belonging to the latter. In its older stages it develops the thick, heavy ribs to which its name refers. In mature shells the section of the whorl is subquadrate, the ribs nearly straight or a little flexed forward near the periphery in examples below a diameter of 5 inches, and it tends to divide, either near the dorsal border, or in some cases above the middle of the side; sides are flattened, sloping toward the periphery. In older stages the shell of the body-chamber departs a little from the earlier whorls. The largest example seen has a diameter of 17 inches.

Shastoceras Anderson, n. genus

The genotype of the present group is its leading species *Shastoceras californicum* nov. The specimen is in the Museum of Paleontology, University of California, and was mentioned by Gabb under the name "*Ancyloceras percostatus*" as being "in the cabinet of Mr. Voy, now deposited in the museum of the College of California." In its final stages the shell of this genus acquires the general form of *Ancyloceras*, leaving the early coiled stage and forming a straightened or gently curved shaft which increases rapidly in section, and finally forming a thick crosier having a narrowed recurved limb. The earlier whorls are sub-elliptical in section, and the early part of the shaft retains this form, but with growth it becomes less compressed; in its body-chamber the shell becomes more inflated, and in the recurved limb it is much reduced in diameter and nearly circular in section; the shell here forms a few strong costal ridges, more prominent on the ventral side. In its younger whorls (at least in one species), there are costal ridges which are interrupted on the ventral border by the development of small bullae which soon disappear with growth.

The surface of the cast is nearly smooth, but fragments of the shell show oblique, relatively fine, rounded costae, especially visible on the shaft; these arise on the dorsal zone and slope forward toward the ventral zone which they cross without interruption. The septa are not perfectly shown on the genotype, but as they appear on a large fragment of *S. behemoth* nov. the first lateral lobe is asymmetrically divided, and its branches are divided in a similar manner. In form and ornamentation the shell resembles the genotype of *Dirrymoceras* Hyatt (*Ancyloceras simplex* d'Orbigny), but as no complete description of this genus has been found which shows its relationship, generic identity cannot be claimed. Spath has included *Dirrymoceras* in his Heteroceratidae, and it is possible that it may include "*Heteroceras*" *tardieui* Kilian (1910, pl. 7). This form begins with helicoid early whorls, differing greatly from those of *Shastoceras* which show no tendency toward helicoid whorls.

Four species of this genus have been found, all of them in nearly the same stratigraphic zone, namely, in the upper part of the Horsetown group (lower Gargasian), and all in the Cottonwood district, Shasta County, above the Mitchell zone, and a little above the zone of *Tropaeum percostatum* (Gabb).

Shastoceras californicum Anderson, n. sp.

(Plate 74, figure 1; plate 78, figure 1)

In Gabb's attempted revision of "*Crioceras*" *percostatus* (Gabb, 1869a, p. 138, 139) he refers to the holotype of this species, now in the Museum of Paleontology, University of California, giving its length as 17 inches. The shell is large, robust, or massive, its general form being that of *Ancyloceras*. The early coil is discoidal, crioceratid, slightly flattened on the dorsum; the shaft increases rapidly in section after leaving the early coil; shell costate, the small rounded costae being oblique, arising in the dorsal zone and crossing the sides with forward inclination at an angle of about 18 degrees from the normal and also crossing the ventral zone without interruption but with reduced strength. On the recurved limb of the crosier a few strong rounded ridges, more prominent on the ventral side, are developed; crosier closely bent on the dorsal side, more broadly curved on the periphery; section of early whorls broadly elliptical, that of the shaft more compressed; section of bucal limb nearly circular. The holotype of the species has a length of 17.5 inches and a width across both limbs of the crosier of nearly 10 inches. The type locality and horizon of this specimen are not definitely known, but the horizon of its known congeners, herein described, is in the upper part of the Horsetown group (lower Gargasian), as found in the Cottonwood district, Shasta County. Many fragments of shells belonging to this genus, but not to one species, have been found on Hulen Creek, and on Mitchell Creek and Roaring River, a little above the zone of *Tropaeum percostatum*, and this is probably the horizon of the holotype of the present species.

Shastoceras shastense Anderson, n. sp.

(Plate 73, figure 3; plate 75, figure 1)

This shell has the form of *Ancyloceras* but is devoid of tubercules and spines, such as characterize this genus. The surface of the shell is smooth, although showing faint rounded, oblique ribs, similar to those of the genotype; section of early whorl and lower part of shaft flattened or moderately elliptical; section of body-chamber more inflated; costae not conspicuous on the shaft, more pronounced on the early coil; bucal limb furnished with heavy transverse ribs, more prominent on the ventral side; section of bucal limb broadly elliptical, flattened on the dorsal border; dorsal border of the shaft nearly straight. In form this species somewhat resembles *Shastoceras californicum* but differs from it in some important respects. The shell is

more inflated, the early coil is broader and more developed, and the ribs on this portion of the shell are strong and rounded and terminate on the ventral border in clearly visible ventro-lateral nodes. The ventral surface of the coil is flattened; with growth the ventral side becomes more rounded, the costal nodes disappear, and the ribs become more numerous and fainter. The early whorls are more nearly of the type shown in *S. behemoth*, figured by Gabb (1869, pl. 24). In section of whorl, shaft, and body-chamber the present species is less inflated, is smaller in size, and the bucal limb is broader and less heavily ribbed. The holotype is the property of the California Institute of Technology and has the following dimensions: total length of shell, 18.5 inches; total width of shell (both limbs), 11 inches; greatest thickness, 3.4 inches; greatest diameter of bucal limb, 4.7 inches; lesser diameter, 3.9 inches. This example was found by W. P. Popenoe and D. W. Scharf on Roaring River, immediately beneath the conglomerate of the Barr zone and not far above the top of the Mitchell zone, east of the Millsap road. Its position marks the lowest known occurrence of this genus in the Cottonwood district.

Shastoceras behemoth Anderson, n. sp.

(Plate 76, figure 1; plate 77, figure 4)

Ancyloceras percostatus GABB (in part), Paleont. Calif., vol. 2, 1869, p. 138, pl. 24, fig. 19 (*not* "*Crioceras percostatus* GABB, vol. 1, 1864, p. 77, pls. 16, 17; Cottonwood Creek).

This remarkable species was known to Gabb, although he confused it with *Tropaeum percostatum* (Gabb). However, both forms were well illustrated by him. Concerning the holotype of the present species (Gabb, 1864, p. 77, pl. 24), he says in part:

"The specimen figured was about thirty inches in length, while one very perfect specimen in the cabinet of Mr. Voy, now deposited in the museum of the College of California, is but 17 inches long."

In this statement Gabb refers to two distinct species represented by the respective specimens. The second specimen mentioned is the holotype of *S. californicum*, as already explained. The first, said to be 30 inches in length, and figured by him (Gabb, 1869, pl. 24), has not been found, nor has any complete example of such size been seen by the writer. Fragments of the species possessing the characters shown in the figure have been obtained, which indicate by their proportional measurements a length of 32 inches. No satisfactory description of the earlier whorls of this form was given, although Gabb's figure indicates a crioceratid coiling, with close-set ribs separated by narrow interspaces. The earliest whorls seem to have been contiguous, since they are slightly flattened on the dorsal border, as seen in a large fragment of the species found at Locality 1857 (Calif. Acad. Sci.) near Mitchell Creek. In size, form, and ribbing, this example corresponds well with Gabb's (1869a, pl. 24) drawing. In section the younger whorls are sub-elliptical and somewhat flattened on the dorsal border; the ribs are low and rounded, inclined a little forward on the sides and slightly tuberculate on the ventral border. This condition of the whorl is soon lost with growth, the periphery becomes rounded, and the ribs become flatter and almost disappear on the shaft. The body-chamber of this species is somewhat inflated, and the recurved limb becomes heavily ribbed on the sides and on the ventral border, but the ribs are much reduced on the dorsal side.

Gabb gave no information as to the horizon of this species, but, as many large fragments which seem to represent it have been found on both Hulen Creek and near

Mitchell Creek, in all cases about 150 to 250 feet above the Argonaut zone, it may be assumed that its horizon is in the upper part of the Horsetown group (lower Gargasian) in the Cottonwood district, Shasta County. The species is not known from any other district.

Shastoceras ventricosum Anderson, n. sp.

(Plate 77, figure 1)

In the collections of the California Academy of Sciences there is a body-chamber of an example representing this genus which possesses some striking features not seen in any of the preceding forms. It represents a mature shell with a much-inflated crosier, although the adjacent parts—namely, the recurved limb and the part of the shaft still remaining—are contracted, especially at and about the aperture, where it shows a few stout ribs, well developed on the outer border. In section the bucal limb is nearly circular rather than elliptical. This specimen is the holotype of the present species (Calif. Acad. Sci. type Coll.). It has the following dimensions: the ventricose crosier has a maximum circumference of 20.3 inches and a maximum diameter of 6.5 inches; greater diameter at the position of the last septum, 6 inches, lesser diameter, 3.3 inches; diameter at end of bucal limb, 4.1 inches; estimated length of complete shell, about 11.5 inches. The suture line is not shown but is supposedly not unlike that of *S. behemoth*. This specimen was found on Hulen Creek in the zone of the preceding species, some 200 feet above the Argonaut zone. Fragments of the species are not uncommon on the west branch of Hulen Creek, but none have been found farther south.

Hamiticeras Anderson, n. genus

Many smaller ancyloceratid forms have been found in the Aptian strata in California and in other countries, which it seems desirable to unite under a new generic name. Among the number obtained in California by Gabb he included at least three species under the name *"Helicancylus" aequicostatus*, but no satisfactory diagnosis of any of them was given. As shown in another place, the name *Helicancylus* properly attaches to only one of these species. To this genus the other forms here mentioned cannot be shown to have close relationship, and for them the name *Hamiticeras* seems to be appropriate and is suggested for the group. The forms here placed under it have the outward aspect of *Hamites* Parkinson (*s. s.*), but they possess distinctly tuberculate ribs, and like Hamitidae seem to have originated in a hoplitid (possibly a parahoplitid) stock. However, in the possession of tuberculate ribs, they differ much from true *Hamites* and from other types included in Hamitidae, as restricted by Spath.

The trituberculate ribs of the genotype, *H. pilsbryi* nov., and the tripartite lobes of the septum seem to place them clearly among the Ancyloceratidae, as emended by Whitehouse. In some characters, namely, in ribbing and perhaps in form, they may represent a development somewhat parallel to that of *Parancyloceras* Spath; among them the ribs on the smaller limb, at least, possess two or three rows of tubercules similar to those of ancyloceratids. The group appears to include *"Ancyloceras" patagonicum* Stolley and perhaps also *"Ancyloceras" obovatum* von Koenen. The smoother or less conspicuously tuberculate forms here included appear to be genetically connected with *Shastoceras* n. gen. *Hamiticeras* may also include some of the tuberculate forms provisionally placed by W. S. Adkins (1928, p. 207–210) under *"Hamites."* Another form described by Gayle Scott (1928, p. 116, pl. 16, figs. 10, 13) may also find a place in *Hamiticeras*.

Hamiticeras pilsbryi Anderson, n. sp.

(Plate 79, figure 1)

Helicancylus aequicostatus GABB (in part only), Paleont. Calif., vol. 2, 1869, p. 141, pl. 25, figs. 20b, c, d, e, f, (? g), all belonging to a single individual; locality not certainly known.

This remarkable species is of medium size; its limbs are circular in section but are diverse in form and ornamentation; the smaller limb, which is also the longer, possesses oblique ribs of two kinds, alternately smooth and simple, and trituberculate thicker ribs; body-chamber sharply bent, not shown in Gabb's figures; ribs on the smaller limb interrupted on the siphonal line by a nearly smooth depression bordered by ventro-lateral tubercules; larger limb heavily costate, with simple non-tuberculate ribs, much stronger than those on the smaller limb; near the dorsal border the ribs are reduced in strength and bent forward; all are more prominent on the ventral side; intercostal spaces broader than the ribs. The trituberculate ribs on the smaller limb show its ancyloceratid character, as do also the septa, as drawn by Gabb (1869, pl. 25, fig. 20g). The several fragments illustrated by Gabb (1869, pl. 25, figs. 20b, c. d. e. f) have no close relation to the others (Gabb, pl. 25, figs. 20, 20a) which belong to a distinct genus. The holotype of this species is in the museum of the Academy of Natural Sciences of Philadelphia and was loaned to the California Academy of Sciences for study and illustration. It has the following dimensions: total length, 92 mm.; maximum diameter of larger limb, 33 mm.; maximum diameter of smaller limb, 26 mm.; width across both limbs, 58 mm. An example of this species has been found by W. P. Popence and D. W. Scharf in the Argonaut zone on the North fork of Cottonwood Creek, near Ono, Shasta County, and the horizon of the holotype is believed to be the same.

Hamiticeras philadelphium Anderson, n. sp.

(Plate 79, figures 2, 3)

In the collections of the Academy of Natural Sciences of Philadelphia there is a well-preserved example of this genus—the holotype of the present species. It bears Gabb's label, *"Helicancylus aequicostatus"* Gabb, and is No. 4797 (Acad. Nat. Sci. Phila.); it is said to have been found on the North fork of Cottonwood Creek, Shasta County. It has the following dimensions: total length, 61 mm.; width across both limbs, 45 mm.; maximum diameter of larger limb, 26 mm.; section of both limbs, nearly circular. A line of faint tubercules appears on the side of the smaller limb, and a row of depressed bullae is shown on the ventral border. As far as can be seen this species is not unlike the figures given by Stolley (1912, p. 11, 14, pl. 1) for *"Ancyloceras" patagonicum*, from the district of Lago San Martin in western Argentina. Stolley regards his species as representing an upper Neocomian or Aptian horizon, perhaps near that of the present species. The nearest European analogue for which a description has been found is *"Ancyloceras" obovatum* von Koenen. Most of the species and examples of *Hamiticeras* so far obtained from the Cottonwood district belong in, or above, the Argonaut zone of the Horsetown group, here regarded as being middle Aptian in age.

Hamiticeras aequicostatum (Gabb)

(Plate 37, figures 2, 2a, 3; plate 79, figure 6)

Ptychoceras aequicostatus GABB, Paleont. Calif., vol. 1, 1864, p. 74, pl. 13, fig. 20; North fork of Cottonwood Creek (not *Helicancylus aequicostatus* GABB, vol. 2, 1869, p. 141, pls. 25, 20, 20a).

Hamites (Ptychoceras) aequicostatus (Gabb) ANDERSON, Calif. Acad. Sci., Pr., 3d ser., vol. 2, 1902, p. 90; Locality as by Gabb.

The holotype of this species, a fragment of the body-chamber only, is in the Museum of Paleontology, University of California. More complete examples of the same species have been obtained from Alderson Creek and have been compared with the holotype. The shell is small, with limbs not closely approximate; the smaller limb has a subcircular section, and that of the larger limb is more nearly circular; both limbs are costate; the ribs on the smaller limb are much more oblique than those of the other; ribs without pronounced ornament, more elevated on the ventral surface; on the smaller limb the ribs are less prominent and the interspaces shallow; some of the ribs on the smaller limb bear faint nodes on the ventral border, but they cross the ventral zone without interruption. The figured specimen (Calif. Acad. Sci. type Coll.) was found on Alderson Creek, in the Alderson zone, associated with *Lytoceras batesi* (Trask) and *Phylloceras aldersoni* nov. Gabb's statement that

"from one imperfect impression, showing 26 ribs, it seems that on a single rib there have been two tubercules, or spines, one near the dorsal and the other near the ventral side," did not refer to his holotype, but to some other specimen not figured. Faint nodes are found on the ventral border of the smaller limb only, as already noted.

Toxoceras d'Orbigny

Toxoceras cornucapri Anderson, n. sp.

(Plate 10, figure 3)

Shell small, openly curved, tapering somewhat regularly, transversely costate, with rounded ribs, most of which bear small, inconspicuous spines on the ventral border and a lesser number on the side of the shell; the ventro-lateral spines are somewhat more prominent than the lateral; the lateral spines seen only at irregular intervals. The curvature of the shell increases gradually with growth, the shell being almost straight at first but curving more rapidly toward the bucal end. This shell resembles *Toxoceras emericianum* d'Orbigny from Vergons (Basses-Alpes), France. The holotype (Calif. Inst. Tech. Coll.) has the following dimensions: length of cone (incomplete), 67 mm.; ventro-dorsal width, 8 mm.; transverse thickness, 7 mm.

This example was found by W. P. Popence and D. W. Scharf on Alderson Creek, half a mile southeast of the Barr ranch house, south of Ono. Its position appears to be below the Argonaut zone of the Alderson Creek section. Its locality number is 969 (Calif. Inst. Tech.) and is not known to have had associates of other species.

HAMITIDAE Hyatt, emend. Spath, 1922

Although Spath has included in this family many later Cretaceous types, only a brief consideration is here given the pre-Cenomanian, costate, and non-tuberculate hamitids, and a single tuberculate form that cannot well be omitted from the list.

The family is here regarded as including the following:

Hamites Parkinson; genotype, *Hamites attenuatus* Sowerby (not d'Orbigny)
Tornutoceras Hyatt; genotype, *Hamites attenuatus* d'Orbigny (not Sowerby)
Helicoceras d'Orbigny; genotype, "*Hamites*" *annulatus* d'Orbigny
Ptychoceras d'Orbigny; genotype, *Ptychoceras gaultianum* (Pictet)

Whitehouse (1926, p. 224–226) has questioned the practical value of *Tornutoceras* as a generic term; he believes that the forms placed under it may well be included in *Hamites*. It would appear also that along with *Ptychoceras* d'Orbigny, it would be permissible to include *Diptychoceras* Gabb; genotype, *Diptychoceras laeve*, and a moderately tuberculate form, both of which are found in the Perrin zone of the Hulen beds in the Cottonwood district. The single unquestionable species of *Hamites* below the Cenomanian is a rather large form found near the middle part of the Albian and is represented by only a fragment of a shell.

Hamites imitator Anderson, n. sp.

(Plate 43, figures 4, 5)

A single fragmentary example of a hamitid species was found in the Perrin zone at Locality 1668 (Calif. Acad. Sci.) in the upper part of the Horsetown group. It seems to be closely related to *Hamites armatus* Sowerby, although it is from a lower stratigraphic horizon, here regarded as middle Albian. As far as the species can be described from this example, it has the following characters:

Shell large, tapering slowly, section of costate limb elliptical, rounded on both dorsal and ventral borders; surface marked by numerous oblique, rounded ribs, separated by wider interspaces, the interval being about 3 mm. broad; ventral zone bordered on both sides by single rows of broad, low, rounded tubercules, which appear upon each third rib, although their exact relation to the rib is not clearly seen; septum as seen in the figure, the lobes and their principal branches being bipartite, in the manner of *Lytoceras*. The holotype (Calif. Acad. Sci. type Coll.) has the following dimensions: length, 67 mm.; dorso-ventral diameter, at larger end, 43 mm.; transverse diameter, larger end, 31 mm.; same diameter at smaller end, 30 mm.

This species has the general characters of *Hamites armatus* Sowerby, as figured by Boule and Thevenin (1906–1907, p. 56) especially with respect to the suture line. The holotype of the present species was associated with *Acanthoplites perrini*, *Cleoniceras leconteï*, *Phylloceras theresae*, and *Diptychoceras laeve* Gabb, all of which are found 100 to 200 feet beneath the Neptune zone in the upper part of the Horsetown group.

Ptychoceras d'Orbigny

Ptychoceras natrice Anderson, n. sp.

(Plate 61, figure 2)

Shell small or of moderate size having the two limbs folded closely together; section of the two limbs subquadrate; smaller limb subcircular in section, nearly smooth, tapering gradually; larger limb quadrate in section, slightly concave on its dorsal contact with the smaller limb; costate, with gently inclined, simple costae crossing the ventral zone as smooth rounded ridges; ventral zone rounded; septa not exposed on holotype. The species belongs to the group represented by *Ptychoceras puzosianum* d'Orbigny, found in the Neocomian (Barremian) of France, which is its nearest known analogue. The holotype (Calif. Acad. Sci. type Coll.) was found in the Mitchell zone at Locality 1657 (Calif. Acad. Sci.) on the west branch of Mitchell Creek, a mile above the mouth of this stream. It has the following dimensions: total length, 52 mm.; transverse measure (both limbs), 24 mm.; height of aperture, 13 mm.; width of aperture, 13 mm.; top of crosier roundly curved. This example was found associated with *Shasticrioceras poniente*, *Pseudocrioceras* sp., and *Inoceramus ovatoides* nov., in strata regarded as upper Barremian in age.

Diptychoceras Gabb

Diptychoceras laeve Gabb

Diptychoceras laevis Gabb, Paleont. Calif., vol. 2, 1869, p. 144, pl. 25, figs. 21, 21a, 21b; "Shasta Group," Cottonwood Creek, Shasta County.

Gabb's account reads in part as follows:

"Shell moderate in size, limbs long and slender, section of the smaller limb subelliptical, slightly flattened on the ventral (dorsal) side; second limb subcircular, very slightly emarginate by the encroachment of the preceding branch; last limb suddenly incurved, and extending to (or beyond ?) the middle of the shell. Surface

plain or polished, ornamented only by a few extremely faint undulations. The outer, or final limb, which is in places very much broken, had one or more constrictions, or internal ribs, which do not seem to have been visible on the external surface; one or two such internal ribs seem to have existed, though in much less degree on the middle limb."

The holotype of this species is in the museum of the Academy of Natural Sciences of Philadelphia and was loaned to the California Academy of Sciences for comparison with others found at the type locality. Three good examples were found in the Perrin zone at Locality 1668 (Calif. Acad. Sci.) associated with *Cleoniceras lecontei*, *Phylloceras theresae*, and other species. According to Gabb (1869a, p. 127), this species was found with *Ptiloteuthis foliatus* and a species of crustacean. Gabb's holotype probably came from Hulen Creek, near the locality mentioned. It has not been found at any other place.

Hamulina d'Orbigny

Genotype, *Hamulina subcylindrica* (d'Orbigny)

Hamulina aldersona Anderson, n. sp.

(Plate 56, figures 2, 2a)

Shell of medium size, limbs moderately separated, straight, finely costate with major and minor costae; section of each limb subcircular; smaller limb septate, the septum resembling that of the genotype; costae on the smaller limb fine, rounded, oblique, separated by wider interspaces; major costae faintly tuberculate on the side, bearing spines on the ventro-lateral and dorsal borders; on the smaller limb, eight to ten finer costae intervene between the major, non-tuberculate costae; on larger limb, costae trituberculate and occasionally spinose; minor costae bearing no tubercules. On the larger limb the costae are oblique near the bend but become less so near the middle and at the extremity of the body-chamber. The holotype of this species was obtained at Locality 1348 (Calif. Acad. Sci.) on Alderson Creek, about 2 miles south of Ono, Shasta County, at a horizon about 200 feet above the Argonaut zone. It resembles *Hamulina lorioli* Uhlig in its circular section, in its abrupt bend, by which the two limbs become nearly parallel, and in its costation, which on the smaller limb is oblique, becoming more nearly normal on the larger limb. In the present species, however, the smaller limb bears a double row of elevated spines on the ventral borders and on the dorsum, with evidence of having had lateral tubercules on the major costae. The holotype (Calif. Acad. Sci. type Coll.) has the following dimensions: total length, 112 mm.; width between limbs, 12 to 15 mm.; maximum diameter of body-chamber, 22 mm.; maximum diameter of smaller limb, 12 mm.

Anahamulina Hyatt

Anahamulina vespertina Anderson, n. sp.

(Plate 23, figures 3, 3a)

Two examples of this species, consisting for the most part of the body-chambers only, were found at Locality 113 (Calif. Acad. Sci.) in the Hamlin-Broad zone, in the upper part of the Paskenta group. The shell is of moderate size, hamitid in its general aspect, closely costate, the costae on the two limbs being dissimilar in both size and direction; costae rounded, with equally broad and rounded interspaces; costae on larger limb crossing it at nearly right angles to its dorsal border, in part branching into two or three divisions below the middle of the side and occasionally at higher points; costae bearing elongated nodes at points of division; costae on smaller limb oblique, inclined strongly forward; in part branching into two or three

divisions, in part single; branching ribs bearing tuberculate nodes at points of division more prominent than on the larger limb; section of limbs subcircular, flattened on the dorsum, where the ribs bend strongly forward; septa only imperfectly shown, sutures similar to those of *Hamulina*. Insofar as the body-chambers indicate, this species has characters similar to *A.* (*"Hamulina"*) *lorioli* Uhlig, described from the Wernsdorfer beds of the Carpathian Mountains, eastern Silesia. As Hyatt included this species in *Anahamulina*, its California analogue should also be admitted.

In form this species is somewhat more robust than Uhlig's, the costae are heavier and less numerous, and the costal nodes are more prominent on the smaller limb, whereas in Uhlig's species they are more prominent on the larger limb. The holotype (Calif. Acad. Sci. type Coll.) has the following dimensions: width of body-chamber across both limbs, 61 mm.; dorso-ventral diameter of larger limb, 21 mm.; diameter of smaller limb, 18 mm.; holotype found 3 miles southwest of Ono, Shasta County.

HETEROCERATIDAE Spath 1924

Hamibaculites Hyatt 1896

Genotype, *"Toxoceras" obliquatum* d'Orbigny

No formal description of this genus has been found in the literature, but, as the genotype is sufficiently characterized and distinctive, a further description may have been thought unnecessary by the author. D'Orbigny makes no statement as to the early stages of the species or to a retroversal body-chamber, if such existed. Few other writers seem to have recognized forms of this group, although it seems to have been well represented in Europe. In the Lower Cretaceous sequence in the Cottonwood district, Shasta County, various distinct species have been found, apparently referable to this genus, the earliest appearing in beds thought to be Barremian (upper "Heteroceratan"), and others at higher levels. These several forms differ much in size, form, surface markings, and other characters, as well as in the horizons of their occurrence. All occur below the top of the Cottonwood Beds (Aptian) and therefore range from Barremian to middle or upper Gargasian.

Hamibaculites mirabilis Anderson, n. sp.

(Plate 78, figures 2, 2a, 3)

Ancyloceras (sp. indet.), GABB, Paleont. Calif., vol. 1, 1864, p. 78, pl. 15, figs. 30, 30a; Cottonwood Creek, Shasta County; (not "*C.*" (*Ancyloceras?*) *Remondi* GABB, Paleont. Calif., vol. 1, 1864, p. 79).

Gabb's confusion of this species with *Hoplocrioceras remondi* (Gabb) seems surprising, even though there is some resemblance in the character of the septum. The species here described is quite distinct and is not closely related to *H. remondi* (Gabb). This form is the largest of the four or five species of the genus found in the Horsetown group in the Great Valley embayment deposits. The holotype of the species has not been recognized, although similar examples are in the Museum of Paleontology, University of California, and others have been found in the field.

According to Gabb's statement, the fragment from which his drawing was made measured 6 inches in length and 2.25 inches in greater diameter. A fragment with nearly these dimensions was found at Locality 1347 (Calif. Acad. Sci.), east of Mitchell Creek, associated with *Phylloceras onoense*, *Belemnoteuthis pacifica* nov., and *Lytoceras argonautarum* (Anderson) in the Argonaut zone, about 200 feet above the Barr conglomerate, and 100 feet above the zone of *Tropaeum percostatum*. The figured example was found by W. P. Popenoe and D. W. Scharf half a mile farther

south at Locality 968 (Calif. Inst. Tech.), and half a mile east of the Jordan house. The stratigraphic position of the species is thought to be upper Aptian (Gargasian).

Hemibaculites nauplius Anderson, n. sp.

(Plate 66, figures 2, 2a)

Shell small, section elliptical, narrowing slightly toward the ventral border, costate, with low rounded, and nearly straight costae, inclining forward and crossing the ventral zone without interruption; ribs non-tuberculate; dorsal zone nearly smooth, showing only depressed costae; septa as shown in the figure. The holotype (Calif. Acad. Sci. type Coll.) was found at Locality 1347 (Calif. Acad. Sci.) near Mitchell Creek, in the Mitchell zone, 5 miles south of Ono, Shasta County. It has the following dimensions: length, 100 mm.; greatest width, 30 mm.; greatest thickness, 22 mm.; shell tapering gradually and showing only a slight tendency to curve. At its larger end there is a slight swelling and possibly the beginning of a more definite curve. Whether this shell possessed a retroversal body-chamber is not known. This species appears to belong to the group of uncoiled ammonoids represented by *"Toxoceras" obliquatum* d'Orbigny, the genotype of Hyatt's genus. It was found at the top of the Mitchell zone, in a bed containing *Shastlerioceras poniente* nov., *Inoceramus ovatoides*, and other species thought to represent an upper Barremian horizon. It is the oldest form of the genus found in the Cottonwood district. Only a single example of the species was found.

Hemibaculites cyclopius Anderson, n. sp.

(Plate 58, figure 3; plate 66, figures 3, 3a)

Shell large, nearly straight, tapering gradually; section broadly ovate, narrowing in outline section toward the ventral border, broadest near the opposite border, a little flattened on the dorsal zone, narrowly rounded on the ventral zone; sides moderately costate, with oblique, rounded, unequal ribs, 2 to 4 mm. in width, arranged in groups of five or six, the central one stronger than the others; costal groups separated by slight depressions; septa shown in the figure. The holotype (Calif. Acad. Sci. type Coll.) has the following dimensions: total length (incomplete), 388.6 mm. (15.3 inches); maximum diameter, 76 mm.; greatest diameter at smaller end, 38 mm.; median diameter, 67 mm. This example was found on Alderson Creek, 2 miles south of Ono, Shasta County, in a shale bed about 200 feet above the horizon of *Tropaeum percostatum* (Gabb), and 800 to 900 feet above the Mitchell zone with *Shastlerioceras poniente* nov. It was associated with *Lytoceras batesi* (Trask), *Acrotauthis impressa* (Gabb), and *Phylloceras onoense* Stanton. This example shows no early coil nor any recurved body-chamber, although it exhibits some evidence of having possessed the latter, having a slight expansion in the ventro-dorsal diameter at its bucal end. This is the longest example of this genus that has been found, although not the largest in diameter, being exceeded in this respect by *H. mirabilis* nov. Only a single specimen of this species has been found.

Hemibaculites nucleus Anderson, n. sp.

(Plate 59, figures 2, 2a, 3)

Shell of medium size, tapering very gradually, only slightly curved, section of shaft broadly elliptical, surface costate, with low, rounded, slightly curving ribs which cross the ventral zone without interruption, becoming faint in the dorsal zone; septa not well preserved. The holotype (Calif. Acad. Sci. type Coll.) consists of a fragment of the shaft which is costate throughout. It measures 81 mm. in length; greatest diameter, 33 mm.; greatest transverse diameter, 30 mm. It was found at

Locality 1657 (Calif. Acad. Sci.) near Mitchell Creek, a mile above its mouth. The horizon was about 250 feet above that of the preceding species. In size, section, and in the character of its ribbing, this species is intermediate between *H. nauplius* and *H. mirabilis*, and its stratigraphic position is likewise intermediate between them. It was found in strata containing *Acrotoulhis aboriginalis*, *Parahoplitoides* cf. *cerrosensis*, and others believed to represent a lower Aptian horizon.

Helicancylus Gabb, emend.

The name *Helicancylus* has been continued in paleontological literature since its first appearance (Gabb, 1869a, p. 140). It seems to have been regarded as a valid generic name by many authors, including Hyatt, J. P. Smith, Spath, and others, and should be retained. Yet an inspection of the figures given by Gabb may well cause suspicion that they are not all identical, specifically or generically. None of them has been indicated as the genotype, but they may readily be seen to include three distinct species; two of them are congeneric, but are not closely related to the third. It seems possible, however, to select one of these as a genotype, and thus preserve the euphonious name *Helicancylus*, without otherwise disturbing its acceptance. But the description given by Gabb so involves the three forms referred to that it should be emended accordingly. Two of the three species more nearly related are described in another place under the name *Hamiticeras* nov. The third form included in Gabb's delineation of the genus (Gabb, 1869a, pl. 25, figs. 20, 20a) represents a helicoid type, but it has no close relationship to the others.

Although this form resembles *Helicoceras*, it is the only one to which the name *Helicancylus* seems to be applicable, and may be regarded as the genotype of *Helicancylus*. This specimen is in the museum of the Academy of Natural Sciences of Philadelphia and is the only example of the genus thus far recognized or recorded from the Lower Cretaceous of California. It is the coil of an immature shell and gives only a partial conception of its mature form. Its asymmetry is readily seen, not only in Gabb's figure, but in the photographs of the specimen here given. Its manner of coiling is thus given by Gabb: "Shell commencing with a dextral, open, descending spiral, as in *Helicoceras*, the spiral afterward opening. . . ." But his statement cannot be followed further without caution. The ribs are all of one kind, arising on the dorsal wall, where they at first curve backward, then ascend nearly normal to the dorsal border and cross the ventral zone without interruption; they are separated by interspaces broader than the ribs; ribs trituberculate, the tubercules first appearing on the ribs at a diameter of 10 or 12 mm., becoming more prominent with the growth of the shell; section of whorl broader than high, the ratio of width to height being about 7:5.5; dorsal walls steep, sides and ventral part of the section rounded, nearly circular; sutures not known. The apparent straightening of the coil in its later stage perhaps led Gabb to associate it with the forms here placed in *Hamiticeras*, but their near relationship can hardly be maintained, even granting that the early stages of the latter are not yet known. Nor is the adult stage of the coil referred to *Helicancylus* yet known, and it should not be assumed from the known data. Some further conception of the genus may be gathered from the description of the only known species, namely, *Helicancylus gabbi* nov.

Helicancylus gabbi Anderson, n. sp.

(Plate 79, figures 4, 5)

Helicancylus aequicostatus GABB (in part only), Paleont. Calif., vol. 2, 1869, p. 141, pl. 25, figs. 20, 20a (not figs. 20, b–g); Cottonwood Creek, Shasta County.

The composite character of "*Helicancylus aequicostatus*" Gabb has already been shown. Nevertheless the name *Helicancylus* may be applied to the coiled form involved in his attempted delineation. Merriam supposed that the holotype of *Helicancylus* was among the materials left at the University of California by the old State Geological Survey. In a list of "type specimens" at the University, prepared by Merriam in 1895, is the name "*Helicancylus aequicostatus*" Gabb. In the Museum of Paleontology there is a small ammonoid bearing this label, but it has no further notation. The label was apparently attached to the specimen by Gabb himself and probably is the specimen referred to by Merriam as the "type." It has a quite symmetrical coil and two types of ribs, and is an example of the young stage of *Australiceras argus* nov., described in this memoir. Incidentally, this is the fourth species that was included by Gabb under the name "*Helicancylus aequicostatus.*" The holotype of *Helicancylus gabbi* nov.—the genotype of *Helicancylus*, as here emended—is in the museum of the Academy of Natural Sciences at Philadelphia, as already stated. As to its locality and horizon, little can be said at present; it is thought to have been found on the Cottonwood Creek near Ono, Shasta County, and to represent an Aptian, or possibly a Barremian, horizon.

BELEMNOIDEA

In the upper Mesozoic, namely, the Knoxville and the Shasta series in California and Oregon, fossil remains of no less than 35 species of cephalopods of the order Belemnoidea are recognizable at present, and there are indications that others will soon be added to the list. Of this number 19 or more are found in the Knoxville series, and at least 16 are confined to the Shasta series. In the Knoxville the great majority of the known species are referable to either *Cylindroteuthis* Bayle and Zeiler, *Belemnopsis* Bayle, or to *Pachyteuthis* Bayle, of which few, if any, survived into Cretaceous time. As far as known, there is little or no relationship between any in the Knoxville assemblage and those in the Shasta series. Nor is their stratigraphic occurrence continuous. Most of the forms constituting the Knoxville assemblage appear to be confined to the upper (Tithonian) part of the series, and at its close they quickly and completely disappear, leaving no recognizable descendants. The earliest faunas referable to the Cretaceous sequence contain no distinct traces of the Knoxville types, whereas the belemnoids of the Shasta series belong to distinct genera, for the most part, such as characterize the early Cretaceous of other regions (England, western Europe, and Russia). In the Cretaceous assemblage the following genera, recognized by Stolley, are fairly well represented, although not equally:

Acroteuthis Stolley,	10 species	*Belemnoteuthis* Pierce,	2 species
Aulacoteuthis Stolley,	2 species	*Belemnopsis* Bayle,	2 species
		Hibolites Montfort,	1 species

From the generic character of this assemblage, as contrasted with that of the Knoxville series, it is believed that they entered the California province as immigrant races, following some profound changes in sea and land conditions in western America and in the Pacific basin, which opened new connections or avenues of migration. Although their stratigraphical order is not yet fully known, some of the Cretaceous assemblage seem to be confined to restricted zones. It is perhaps too early in their study to give the vertical range of many of them, although we may note the zones in which they have been found up to the present.

The earliest representatives of the order appear in almost the lowest Cretaceous

strata, as in the basal conglomerates of the Paskenta group, with which are associated various evidences of disturbance and of unconformity. They increase in numbers and variety through the lower part of the Horsetown group. At its top, or in beds that may represent its latest epoch, the last of the belemnoids in the California province appears in a single species of *Neohibolites*, although it is rather widely separated stratigraphically from any earlier known form. By far the greater number of species and individuals occur in the lower and middle parts of the Shasta series (mid-Valanginian to mid-Aptian). The earliest forms seem referable to the genus *Acroteuthis* Stolley, and most of the succeeding forms belong to this group, although they show considerable variety, among which at least 10 species are recognizable. Although present knowledge of the assemblage and of the vertical range of its various species is incomplete, the following tentative table shows their known distribution:

TABLE 3.—*Vertical distribution of Belemnoidea in the Shasta series*

Horsetown group	Albian	Buenaventura zone	*Neohibolites fontinalis* nov. *Ptiloteuthis foliatus* Gabb
	Aptian	Argonaut zone	*Belemnoteuthis* sp. nov.
	Barremian	Barr zone	*Acroteuthis aboriginalis* nov. *A. barrana* nov.
		Mitchell zone	*Hibolites cigarroides* nov. *Acroteuthis mitchelli* nov. *Acroteuthis impressa* (Gabb)
	Hauterivian	Ono zone	*A. shastensis* nov. *Hibolites diventroides* nov. *Acroteuthis kernensis* nov. *A. onoensis* nov.
Paskenta group	Valanginian	Hamlin-Broad zone	*A. shastensis* nov. *A. impressa* (Gabb) *A. wilcoxi* nov. *Belemnoteuthis pacifica* nov.
	Infra-Valanginian		*Acroteuthis wilcoxi* nov. *A. kernensis* nov. *A. cf. shastensis* nov. *A. winslowensis*

BELEMNITIDAE de Blainville

Acroteuthis Stolley 1911

Acroteuthis impressa (Gabb)

(Plate 81, figure 6; plate 82, figure 1, 1a, 1b)

Belemnites impressus GABB, Paleont. Calif., vol. 1, 1864, p. 58, pl. 9, figs. 2, 2a; North fork of Cottonwood Creek, Shasta County; vol. 2, 1869, pp. 128, 209; "Shasta group"—STANTON, U. S. Geol. Surv., Bull. 133, 1895, p. 84 (in part, pl. 20, figs. 1, 2, 5).

Acroteuthis impressa (Gabb) STOLLEY, Foss. Catal., 1920, p. 207.

The holotype of this species is in the Museum of Paleontology, University of California, and has been carefully studied and compared with many forms from the Shasta series in California. The holotype has a total length of 172 mm. and a maximum normal diameter of 25 mm.; it is nearly circular in section but at the upper end has been crushed and flattened, giving it the appearance of having a flare, as is shown in Gabb's figure. This flare is obviously due almost entirely to crushing and is accordingly negligible. On the side figured by Gabb this is almost covered by a thin layer of the prolonged guard, but on the opposite side the wholly septate wall of the phragmacone is exposed, protruding from the upper end of the rostrum about 45 mm. on this side. Critical measurements of the holotype necessitate some emendment of its description. The actual dimensions of the rostrum, below the point at which the "flare" begins, are as follows: total length, 127 mm.; maximum diameter, 25 mm. Gabb's figure of the holotype does not conform to the facts and makes the form appear much more slender. The apical angle of the phragmacone cannot be determined from the holotype but, as found in other examples and as indicated in the figure of the plesiotype, it extends through about one-fifth of the guard, and the angle is about 26 degrees. There is no evidence in any of the examples studied that the axis of the phragmacone, or of the guard, is excentric; on the contrary, it is normally central to the guard. The figured plesiotype (Calif. Acad. Sci. type Coll.) was found with others of the same species in the Mitchell zone in the lower part of the Horsetown group, at Locality 1347 (Calif. Acad. Sci.), on Mitchell Creek, about 6 miles south of Ono, Shasta County. It occurs in the same zone on the North fork of Cottonwood Creek and in other places and is usually associated with *Shastiriocceras poniente* or with some form of *Ancyloceras*, indicating that its horizon is a little lower than Aptian. It has also been found below the Mitchell zone. It has been reported from near Wilbur Springs, Colusa County, in strata of probable Paskenta age. Gabb's reference to its occurrence near Mount Diablo, associated with *Aucella piochi*, is probably due to mistaken identity. It does not seem to have been found at any place in the Knoxville series (Tithonian) in either California or Oregon.

Acroteuthis aboriginalis Anderson, n. sp.

(Plate 80, figure 2)

The guard of this species is the largest yet described from the Cretaceous of California. The guard of the holotype (Calif. Acad. Sci. type Coll.) has a length of nearly 7 inches (175 mm.) and a width of 30 mm. The ventral side is marked by a broad shallow groove extending from near the apex along the lower one-third of the guard; guard tapering from near the middle, rounded on the back; section nearly circular; section of phragmacone circular, concentric to the surface, axis nearly central. This species is not uncommon in the Barr zone near the middle of the

Horsetown group, 6 miles south of Ono, Shasta County. The holotype and other examples were found at Locality 1347 (Calif. Acad. Sci.) associated with *Nautilus averilli* nov., *Parahoplitoides* sp., and other ammonoids of the Barr zone. The guard of this species is very similar in size, form, and surface appearance to that of the European species "*Belemnites*" *magnifica* d'Orbigny, as figured by Pavlow and Lamplugh; according to Stolley (1920, p. 208), the latter form is included in *Acroteuthis*. It has not yet been found in any other district or horizon in California.

Acroteuthis shastensis Anderson, n. sp.

(Plate 81, figure 5)

Belemnites impressus STANTON, in part (not GABB), U. S. Geol. Surv., Bull. 133, 1895, p. 84, pl. 20, figs. 3, 4; "Lower Horsetown beds," neighborhood of Ono, Shasta County.

Acroteuthis impressa (Stanton) STOLLEY, Foss. Catal., 1920, p. 207 (in part, STANTON, U. S. Geol. Surv., Bull. 133, 1895, pl. 20, figs. 3, 4).

This species is obviously distinct from "*Belemnites*" *impressus* Gabb, and its stratigraphic range in the Shasta series is lower. A comparison of many examples from both the Cottonwood and McCarthy Creek districts confirms this view. In the present species the guard is relatively thicker, and the form is accordingly more robust. The guard is heavy, the sides nearly parallel for most of its length, but tapers to a blunter point than in *A. impressa* (Gabb). The ventral groove is broad, moderately deep, roundly concave at bottom, and extends downward nearly to the point. The phragmacone is circular in section, the sides forming an angle of about 19 degrees; the axis is somewhat central, but slightly nearer the ventral side of the guard. The holotype (Calif. Acad. Sci. type Coll.) was found at Locality 113 (Calif. Acad. Sci.), near the head of Mitchell Creek, 4 miles southwest of Ono, Shasta County. It has the following dimensions: length (incomplete), 152 mm.; greatest diameter, 31.7 mm.; length of phragmacone, 75 mm. The walls of the alveolus are thin above, much thicker below. Good examples of the species were obtained on the Middle fork of Cottonwood Creek, Shasta County, from Redbank Creek, Tehama County, and from points farther south. This species appears to belong to the group of "*Belemnites*" *magnificas* d'Orbigny as stated by Stanton (1895, p. 84). The holotype was found with *Polyptychites shastensis* nov. and other species of this genus in the Hamlin-Broad zone of the Paskenta group.

Acroteuthis kernensis Anderson, n. sp.

(Plate 80, figure 5)

The guard of this species is of moderate size, nearly circular in section; sides nearly parallel for much of its length, tapering in the lower one-third to an acuminate point; ventral groove deep and broadly V-shaped, extending to the lower one-sixth of the guard; ventral surface flattened below; phragmacone circular, central above; axis inclining a little toward the ventral side; sides of phragmacone forming an angle of about 18 degrees, extending one-third the length of the guard. The holotype (Calif. Acad. Sci. type Coll.) was found by G. D. Hanna and C. C. Church at Locality 27605 (Calif. Acad. Sci.), in the west half of section 32, T. 25 S., R. 18 E., on the northeast slope of Orchard Peak, Kern County. This example represents the lower two-thirds of the guard and shows no alveolar pit. It has the following dimensions: length, 98 mm.; thickness, 20 mm.; total length (est.), 149 mm. This species is closely related to *A. mitchelli* nov. from the lower part of the Horsetown group in the Cottonwood district, where both species have been found. It is more slender than *A. mitchelli*, the ratio of length to width is greater, and the ventral groove is

relatively narrower. The holotype was found with *Lytoceras saturnale*, *Acroteuthis shastensis*, *Aucella solida* Lahusen, and *A. inflata* Toula. According to information given by the collectors, all these species came from the lowest sedimentary beds exposed in this district, with the exception of some thought to belong to the Franciscan series. A specimen of *A. kernensis* has been found in the upper part of the Paskenta group in the Hamlin-Broad zone in the Cottonwood district, and apparently also in the Ono zone near Ono, Shasta County.

Acroteuthis kewana Anderson, n. sp.

(Plate 24, figures 3, 4)

Guard moderately stout, short, somewhat fusiform in outline, the sides converging slightly upward as well as toward the apex; ventral groove pronounced, deep, extending nearly to the apex; phragmacone short, angle of its sides about 30 degrees; axis excentric, nearer the ventral groove; apex acuminate. The holotype (Calif. Acad. Sci. type Coll.) has a total length of 93 mm.; greatest diameter, 21 mm.; depth of alveolus, 22 mm.; width of alveolus at top, 11 mm. The species has some resemblance to *A. onoensis* nov., especially in size and excentricity of axis, but it is more robust and differs notably in outline of guard. The holotype and large fragments of other examples of the species were obtained by W. S. W. Kew and Carl Bremner on Honda Creek, 3.3 miles southwest of Lompoc, Santa Barbara County, at the west end of the Santa Ynez range; they were associated with species of *Aucella* resembling *A. lahusemi* Pavlow. As other species of Lower Cretaceous *Aucella* have been found a few miles farther east in the same range, it is probable that *A. kewana* also represents a Lower Cretaceous horizon, not higher than the top of the Paskenta group of the Shasta series.

Acroteuthis onoensis Anderson, n. sp.

(Plate 31, figures 3, 3a)

In outward appearance the guard of this species has some resemblance to that of *Acroteuthis impressa* (Gabb), although it is relatively a little more slender and possesses a more acuminate point. In section it is subcircular, the dorso-ventral diameter being a little greater than that at right angles, and the ventral surface is a little flattened. The ventral groove is moderately developed and terminates much above the apex. The axis of the guard and of the phragmacone is excentric, being a little nearer the ventral side of the guard, as shown in the figured section. No complete example of this species has yet been found, although the form is well known in the lower part of the Horsetown group in the Cottonwood and McCarthy Creek districts, and has been found farther south. The holotype (Calif. Acad. Sci. type Coll.), representing the upper four-fifths of the guard, includes most of the phragmacone. It has the following dimensions: length (incomplete), 125 mm.; width of the guard, 20.3 mm.; dorso-ventral diameter, 20 mm. or less. This example was found a little above the Mitchell zone in the lower part of the Horsetown group, at Locality 1657 (Calif. Acad. Sci.), on Mitchell Creek, half a mile north of Roaring River. Fragments of the same species have been found in the lower part of the group and at the top of the Paskenta group on the Cottonwood Creek, near Ono.

Acroteuthis wilcoxi Anderson, n. sp.

(Plate 31, figures 1, 1a, 2)

Belemnites sp. (?), Stanton, U. S. Geol. Surv., Bull. 133, 1895, p. 85; Shelton's ranch, 5 miles north of Paskenta, Tehama County.

Although Stanton seems to have noticed the species he did not have examples complete enough for a satisfactory description and illustration, and this condition has been but little improved since. Many fragments have been found in the area between Elder and Thomes creeks, Tehama County, and similar fragments have been found in the upper part of the Paskenta group in the Cottonwood district, Shasta County. According to Stanton's partial description:

"It apparently has about the form of *B. tehamaensis*, but the alveolus, with an apical angle of about 26°, is inclined toward the ventral side, so that its apex is midway between the center and the ventral side, making the axis of the guard very eccentric."

In the excentricity of its axis this species resembles *A. onoensis* nov. but, in addition to having a thicker and stouter guard and a more nearly circular section, it represents a lower position in the section, namely, for the most part the uppermost portion of the Paskenta group. The holotype (Calif. Acad. Sci. type Coll.) consists of a fragment of the upper half of a guard, having a length of 38 mm. and a lateral diameter of 27 mm. It contains the lower part of the alveolar pit, which is excentric to the surface of the guard, and shows the axis inclined toward the ventral side. At its lower end the axis is midway between the center of the guard and its ventral surface. The figured examples were obtained on the Wilcox ranch, 5 miles north of Paskenta, where they were associated with *Aucella crassa*, *A. crassicollis*, *Dichotomites gregersoni* nov., and *Bochianites paskentaensis* nov. Its stratigraphic position is in the upper part of the Paskenta group.

Acroteuthis mitchelli Anderson, n. sp.

(Plate 80, figures 1, 1a)

The guard of this species is rather large, with sides nearly parallel in the upper half but tapering to an acuminate point below; the section of the guard is subcircular above, but becomes somewhat flattened below, the lateral diameter being greater than the dorso-ventral; ventral groove deep and broad, extending along most of the guard, and terminating below at a point near the apex. Apparently the phragmacone is concentric with the sides of the guard, and no evidence has been seen that the axis is excentric. The holotype (Calif. Acad. Sci. type Coll.) was found in the Mitchell zone of the Horsetown group, at Locality 1657 (Calif. Acad. Sci.), not far above the mouth of Mitchell Creek, 7 miles south of Ono, Shasta County. It has the following dimensions: length of guard (incomplete), 115 mm.; greatest diameter, 21 mm. The species appears to be related to *A. kernensis* nov. but is larger, has a broader and longer ventral groove, and a relatively broader section. Its stratigraphic position is also higher in the Shasta series, being but little below the Barr zone, whereas the highest position of *A. kernensis* yet found was in the Ono zone, near Ono. *A. mitchelli* has been found on Fiddler Creek, associated with *A. shastensis* and *Shasticrioceras poniente*, in strata thought to be of Barremian age.

Acroteuthis barrana Anderson, n. sp.

(Plate 82, figures 2, 2a)

The guard of this species is relatively short and stout and somewhat conical in form; the section is subcircular, flattened on the ventral side; lateral diameter a little greater than the dorso-ventral; ventral groove broad and shallow, extending from the lower part of the alveolar pit to near the apex of the guard; alveolar pit concentric with the sides, central, short. The holotype (Calif. Acad. Sci. type Coll.) was found in the Barr zone at Locality 1347 (Calif. Acad. Sci.) in the lower part of the

Horsetown group on Mitchell Creek, where it is associated with *A. aboriginalis* nov., *Parahoplitoides* sp., *Nautilus averilli* nov., and *Aucella* sp., with striae radiating from the beak. It has the following dimensions: length (incomplete), 84 mm.; greatest lateral diameter, 23 mm.; dorso-ventral diameter, 21.5 mm.; phragmacone broad and short.

The ventral side is but little curved longitudinally, whereas the dorsal side is arched, thus inclining the apex toward the ventral side. Only a single example of this species has been found.

Acroteuthis divergens Anderson, n. sp.

(Plate 80, figures 6, 6a)

The complete guard of this species is evidently very long, although it is known only from fragments, the longest of which is the holotype. This consists of the central portion of the guard. At the top it shows the outline in section of the lower part of the phragmacone, which is centrally placed and extends below the top of the ventral groove, uniting with a centrally placed axis. The section of the guard is subcircular, narrower at the top, and increasing in diameter downward. The most striking feature of the guard is the divergence of its sides downward below the terminus of the phragmacone. The ventral furrow is rather broad and shallow; the length of the holotype and its divergent sides indicate that the original length was as much as 140 mm.; it could have been greater. The holotype (Calif. Acad. Sci. type Coll.) measures: length (incomplete), 98 mm.; diameter at top, 20 mm.; diameter at lower end, 23 mm. This example was found in the lower part of the Mitchell zone on Fiddler Creek, 10 miles south of Ono, Shasta County, where it was associated with *A. shastensis*, *Shasticrioceras* sp., and species of *Terebratula*. It has some resemblance to, although not a near relationship with, *A. mitchelli*, from which it differs in section, in the smaller depth of the ventral furrow, and in the divergence of its sides.

Aulacoteuthis Stolley 1911

Genotype, *Belemnites absolutiformis* Sinzow

Aulacoteuthis wynoonium Anderson, n. sp.

(Plate 80, figures 4, 4a; plate 81, fig. 4)

The guard of this species is small, transversely elliptical in section, with a deep and broad ventral furrow extending nearly the entire length of the guard; guard slightly fusiform, broadly rounded on the dorsal side, tapering to an acuminate point; axis of guard very excentric, situated near the ventral furrow, as seen at the extremities of the holotype. The holotype (Calif. Acad. Sci. type Coll.) was found a little below the horizon of *Tropaeum percostatum* (Gabb), and probably in the Argonaut zone, on Fiddler Creek, 10 miles south of Ono, and about 1½ miles above its mouth, in the lower part of the Horsetown group, and above the position of the Mitchell zone with *Shasticrioceras* sp. The holotype has the following dimensions: length (incomplete), 75 mm.; greatest diameter, 13 mm.; axis excentric, phragmacone not shown.

A near foreign analogue of this species seems to be "*Belemnites*" *absolutiformis* Sinzow, which has been taken by Stolley as the genotype. As figured by Pavlow and Lamplugh (1892a, pl. 7, figs. 11, 12), from "Bed B," at Speeton, there is great resemblance, although not sufficient to prove identity. Fragments of this species were found in the same horizon on the North fork of Cottonwood Creek, associated with *Lytoceras aulacum* nov., *Potamides diadema*, and *Plicatula variata* Gabb.

Acroteuthis winslowensis Anderson, n. sp.

(Plate 83, figures 1, 1a)

The guard of the species is large and heavy, with thick, dense walls, and a relatively narrow alveolar pit and phragmacone. The guard is subcircular in section, the lateral diameter being greater than the dorso-ventral; sides generally parallel in the upper half, sloping to a blunt point below; phragmacone and axis nearly central, a little nearer the ventral side; alveolus apparently deep, the sides forming an angle of 15.5 degrees; ventral groove deep and narrow, extending nearly the entire length of the guard. The holotype (Calif. Acad. type Coll.) has the following dimensions: length (incomplete), 147 mm.; dorso-ventral diameter, 30 mm.; lateral diameter, 35 mm.; depth and width of ventral groove, 6.5 mm.

This species is related to *Acroteuthis shastensis* nov., from the upper part of the Paskenta group, of which it may be a precursor. When complete, this example must have measured 160 mm. in length. The holotype was found by T. H. Crook on Elk Creek, about 2½ miles north of the Winslow bridge, western Glenn County, in the lowest beds of the Paskenta group, Shasta series, a little above the basal conglomerate, and 300 to 400 feet beneath the second conglomerate of the series.

Acroteuthis macarthyensis Anderson, n. sp.

(Plate 83, figure 6)

The guard of this species is rather short and robust, tapering uniformly to a point; guard sub-quadrate in section, this feature forming one of its chief characteristics; ventral surface flattened at the forward end, sulcate near the apex, with a rather broad groove; phragmacone occupying nearly one-half the length of the guard, axis central. The holotype (Calif. Acad. Sci. type Coll.) has the following dimensions: length, 115 mm.; diameter, 20 mm.; ventral groove about 50 mm. in length, extending to the apex.

This example was found by C. M. Cross at Locality 28107 (Calif. Acad. Sci.), on McCarthy Creek, Tehama County, in a near basal bed of the Paskenta group. In form, though not in size, it greatly resembles *Acroteuthis subquadratus* Roemer, as illustrated by Pavlow and Lamplugh (1892a, pl. 3).

Belemnopsis Bayle (*Hibolites* de Montfort)

Belemnopsis (*Hibolites*) *cigarroides* Anderson, n. sp.

(Plate 80, figure 7)

Hibolites cigarroides ANDERSON, Geol. Soc. Am., Bull., vol. 44, 1933, p. 1264, "Zone S," McCarthy Creek section, Tehama County.

The guard of this species is small, fusiform, tapering gracefully toward both extremities from near the middle, terminating below in a sharply acuminate point; ventral groove, if it exists, is scarcely visible, or is marked only by a flattened zone; section of guard nearly circular; phragmacone not exposed, axis seemingly central. The holotype (Calif. Acad. Sci. type Coll.), the only complete example found, has the following dimensions: length (incomplete), 81 mm.; diameter at middle, 10 mm. This specimen was found in the lower part of the Horsetown group ("Zone T"), on McCarthy Creek, Tehama County, about 1200 feet west of the Lowry-Paskenta road. It was associated with *Acroteuthis onoensis* nov. and *Inoceramus colonicus* nov. The species greatly resembles *Hibolites jaculum* (Phillips) from the Neocomian of England and may possibly belong to the same group. The only other example thought to belong to this genus—*Belemnopsis diventroides*—was found in nearly the same horizon on Fiddler Creek, 10 miles south of Ono, Shasta County.

Belemnopsis (*Hibolites*) *diventroides* Anderson, n. sp.

(Plate 80, figures 3, 3a, 3b)

Only fragmentary examples of this species have yet been found. Two such fragments found near together seem to have been parts of a single individual and have been figured as such. Both show the characteristic diventroid section and rounded dorsal side of the guard. Nevertheless, the larger of these fragments is taken as the holotype, to which the other may be regarded as supplementary. In the holotype (Calif. Acad. Sci. type Coll.), the dorsal side is semicircular in section, whereas the ventral side is traversed by two parallel grooves, between which there is a low, rounded ventral ridge, of which the curvature has a shorter radius. The guard is slightly fusiform, tapering from near the middle toward both ends, but more rapidly toward the apex. The holotype has the following dimensions: length (incomplete), 64 mm.; maximum diameter, 9.5 mm. It was found in the lower part of the Horsetown group on Fiddler Creek, half a mile north of the big bend of the creek at which the Mitchell zone is exposed, and not less than 600 feet beneath it. The nearest known analogue appears to be "*Belemnites*" *bicanaliculata* de Blainville, as figured by d'Orbigny (1842, pl. 3, figs. 13–16), which Stolley places in the genus *Hibolites* de Montfort. According to d'Orbigny (1850, p. 62), this species is of Neocomian or lower Neocomian age.

Neohibolites Stolley 1911

Neohibolites fontinalis Anderson, n. sp.

(Plate 81, figures 7, 8)

Belemnites sp. Anderson, Calif. Acad. Sci., Pr., 3d ser., vol. 2, 1902, p. 146, pl. 8, figs. 169, 170; Texas Springs, Shasta County.

The guard of this species is long and slender, slightly fusiform in its lower two-thirds, expanded in its alveolar portion; section of guard nearly circular, axis central; phragmacone only slightly inserted, with an apical angle of about 26 degrees; ventral groove rather faint, not showing on the holotype; apex acuminate. The holotype (Calif. Acad. Sci. type Coll.) measures: length, 98 mm.; greatest diameter, 7 mm.; diameter below alveolus, 5 mm. This example, with various others less complete, was found at Texas Springs, 3 miles east of Horsetown, associated with *Sonneratia stantoni*, *Beudanticeras haydeni*, and *Terebratella densleonis* Anderson. The species has some resemblance to *Neohibolites ultimus* (d'Orbigny) from the Cenomanian of England, but its relation is perhaps only generic. It is longer, more slender, and has a more acuminate point. Its horizon, as shown by its associates, is near that at Horsetown which is believed to be near the upper limit of the group. It has been thought by earlier writers to represent the lowest beds of the Chico series; in either case the horizon is in the upper part of the Albian.

Belemnoteuthidae Zittel

Belemnoteuthis Pierce (*Conoteuthis* d'Orbigny)

Belemnoteuthis (*Conoteuthis*) *pacifica* Anderson, n. sp.

(Plate 77, figures 2, 3)

Phragmacone large, circular in section, apparently straight, tapering slowly; septa thin, numerous, "nested"; holotype (Calif. Acad. Sci. type Coll.) is an incomplete example, showing only eight septa; diameter of largest septum, 76 mm.; diameter of smallest septum, 65 mm.; deeply and uniformly concave; average interval at center, 5 mm.; total length of holotype (est.), 200 mm.; phragmacone without guard

or calcareous sheath; surrounded by only a thin horny envelope, crystallizing in minute prisms; siphuncle small, marginal, consisting of short funnels, pinched at the perforations, expanding between the septa toward the apex of the cone; other characters not known. A small fragmentary example found with the holotype, showing 10 septa, has a total length of 40 mm. and a maximum diameter of 29 mm.; if this represents the anterior end of the phragmacone, its computed length would be not less than 160 mm. In this example the envelope consists of three thin concentric layers, the central one being thicker than the others and showing the trace of the septa on its outer surface. Three examples were found at the type locality, Loc. 113 (Calif. Acad. Sci.), at the head of Mitchell Creek, 4 miles southwest of Ono, Shasta County. The holotype was associated with *Polyptychites shastensis*, *Lytoceras saturnale*, *L. aulacum*, and *Acroteuthis shastensis*, in the upper part of the Paskenta group.

SEPIOIDEA Zittel

CHONDROPHORIDAE Fischer

Ptiloteuthis Gabb

Ptiloteuthis foliatus Gabb

Ptiloteuthis foliatus GABB, Paleont. Calif., vol. 2, 1869, p. 128, pl. 19, fig. 4; "Shasta Group," Cottonwood Creek, Shasta County.

This unusual species, the only one of its order yet described from the Cretaceous of California, is known only from Gabb's drawing and description. Along with his figure of the species, Gabb (1869a, pl. 19, figs. 2a–f) also illustrates various fragments of crab claws, of which he says (p. 127):

"They are from a dense gray claystone, associated with *Ptiloteuthis foliatus* and *Diptychoceras laevis*, from the vicinity of Cottonwood Creek."

This note serves to indicate the horizon of all three species, since they have been found only at Locality 1668 (Calif. Acad. Sci.) on the west branch of the east fork of Hulen Creek, in the Perrin zone of the Horsetown group. Here, many crustacean remains similar to those figured by Gabb have also been found by the writer. None of these species has been found at any other place; all probably came from the abundant gray concretions found in this zone.

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EXPLANATION OF PLATES

PLATE 1.—CRETACEOUS FOSSILS FROM CALIFORNIA

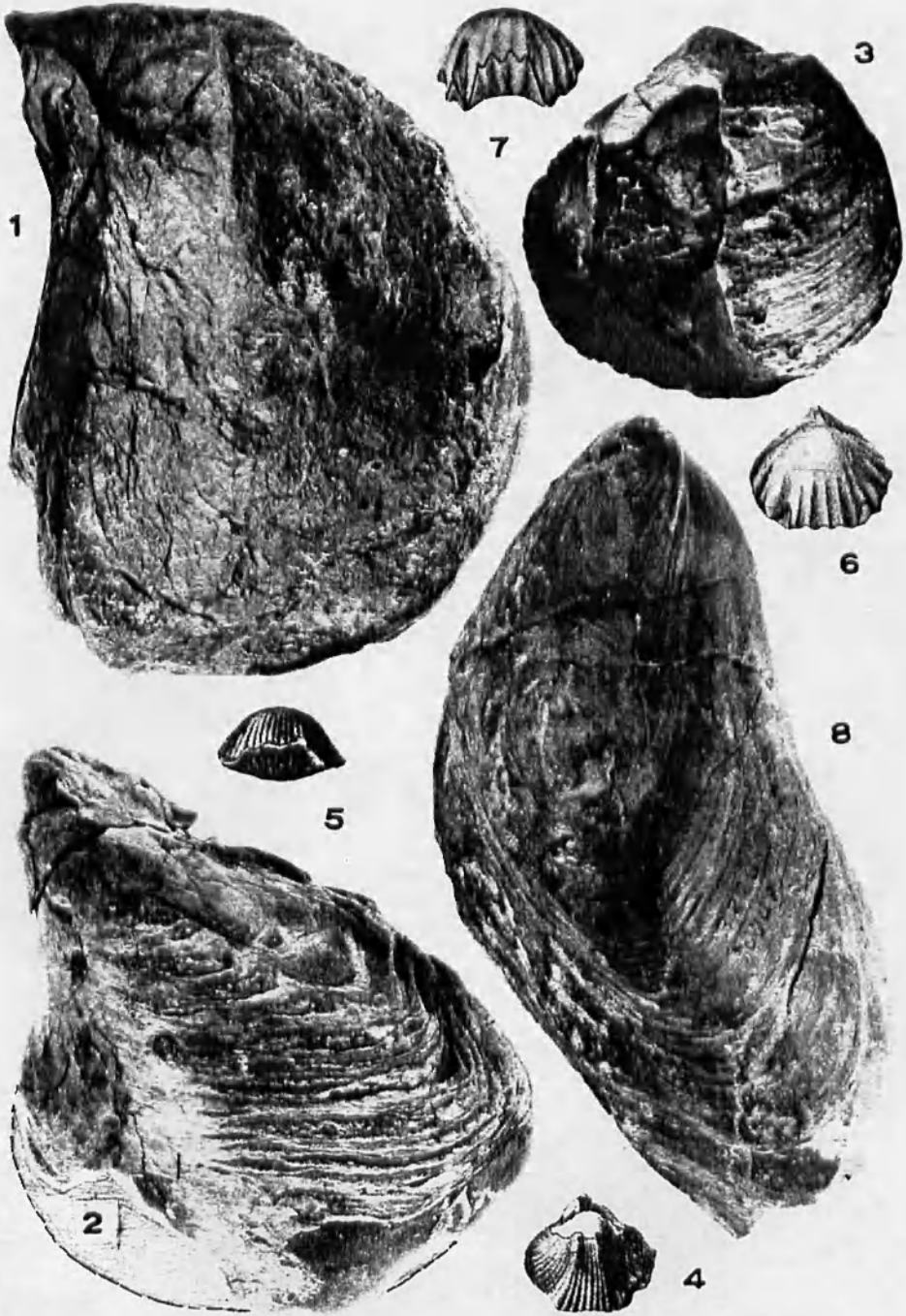
(1, 2) *Ostrea indigena* nov. Holotype and paratype. (1) Holotype, right valve; length, 145 mm.; width, 95 mm. (2) Paratype, left valve; length, 130 mm. Paskenta group, Cottonwood district. p. 108.

(3) *Venus collinium* nov. Holotype, right valve; length, 39 mm.; height, 39 mm. Upper part of Paskenta group; Loc. 113 (C. A. S.), Hamlin—Broad zone, Cottonwood district. p. 122.

(4, 5) *Terebratella whiteana* (Anderson). Reproduction of original drawings. (4) Upper view of holotype. (5) Front view of holotype. Length, 13 mm.; width, 15 mm. Upper part of Horsetown group; Loc. 1344 (C. A. S.), old Horsetown, Shasta County. p. 94.

(6, 7) *Terebratella dentleonis* (Anderson). Reproduction of original drawings. (6) Upper view of holotype. (7) Front view of holotype. Length, 14 mm.; width, 17 mm. Upper part of Horsetown group; Loc. 1344 (C. A. S.), old Horsetown, Shasta County. p. 94.

(8) *Mytilus arlingtoni* L. W. Henry. Holotype, left valve; length, 91 mm.; height, 40 mm. Lower part of Paskenta group; north border of Berkeley, Berkeley Hills, Contra Costa County. p. 113.



CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 2.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1) *Pinna equivillana* nov. Holotype. Length (incomplete), 144 mm.; greatest width, 70 mm. Perrin zone, upper part of Horsetown group; Loc. 1668 (C. A. S.), east branch of Hulen Creek, Shasta County. p. 98.

(2) *Pinna pontica* nov. Holotype. Length (incomplete), 68 mm.; greatest width, 35 mm.; lower part of Horsetown group; Loc. 1353 (C. A. S.), Cottonwood Creek, near Ono, Shasta County. p. 98.

(3, 4) *Nemodon brewerianus* (Gabb). Topotype, North fork of Cottonwood Creek. (3) Left valve; length, 33 mm.; height, 21 mm. (4) Inner view of specimen, showing hinge plate; basal beds of Chico series; Loc. 1346 (C. A. S.), Cottonwood Creek, Shasta County. p. 96.

(5) *Modiolus* (*Volsella*) *onoensis* nov. Holotype, right valve; length, 47 mm.; height, 17 mm. Lowest bed of Horsetown group; Locality, North fork of Cottonwood Creek, near Ono, Shasta County. p. 114.

(6) *Modiolus* (*Volsella*) *henryi* nov. Holotype. Length, 29 mm.; height, 13 mm. Lower part of Paskenta group; north border of Berkeley, Berkeley Hills, Contra Costa County. p. 114.

(7) *Periplomya trinitensis* nov. Holotype. Length, 52 mm.; height, 27 mm.; Upper part of Paskenta group; Clementa Ranch, Trinity County, California. p. 118.

CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 3.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1, 2) *Pholadomya hulenana* nov. Holotype. (1) Left valve. Length (incomplete), 50 mm.; height, 40 mm. Perrin zone, upper part of Horsetown group; Loc. 1668 (C. A. S.), Hulen Creek. (2) Front view of same example. p. 115.

(3) *Pholadomya clementina* nov. Holotype, enlarged. Length, 37 mm.; height, 28 mm. Upper part of Paskenta group; Clements ranch, Trinity County. p. 116.

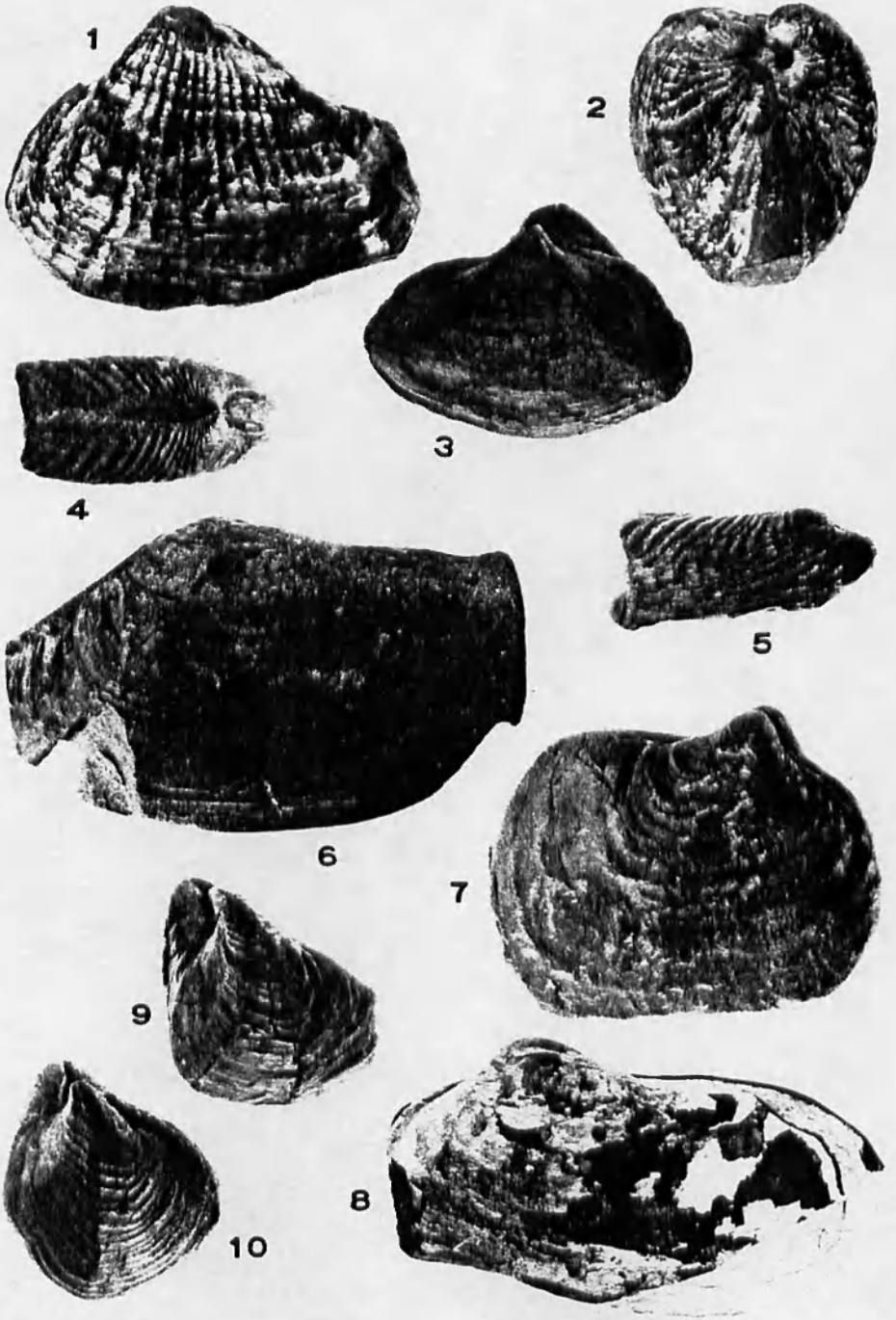
(4, 5) *Goniomya vespera* nov. Holotype, enlarged. Length, 19 mm.; height, 9 mm. (4) Top view. (5) Side view. Upper part of Paskenta group; Loc. 1691 (C. A. S.), Clements ranch, Trinity County. p. 117.

(6) *Panopa subaequilateralis* nov. Holotype. Length, 86 mm.; height, 55 mm. Upper part of Horsetown group; Loc. 1344 (C. A. S.), old Horsetown, Shasta County. p. 124.

(7) *Panopa shastacola* nov. Holotype. Length, 58 mm.; height, below beak, 48 mm. Upper part of Horsetown group; Loc. 1344 (C. A. S.), old Horsetown, Shasta County. p. 124.

(8) *Periplomya reddingensis* nov. Holotype. Length, 59 mm.; height, 32 mm. Upper part of Paskenta group; Loc. 1691 (C. A. S.), Clements ranch, Trinity County. p. 118.

(9, 10) *Pholadomya distorta* nov. (9) Holotype. Length, 35 mm. Upper part of Paskenta group; Loc. 1691 (C. A. S.), Clements ranch. (10) Plesiotype. Upper part of Horsetown group; Loc. 1344 (C. A. S.), old Horsetown, Shasta County. p. 117.



CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 4.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1-3) *Plicatula onoensis* nov. (1) Holotype, upper valve, natural size. (2) Paratype, lower valve, natural size. (3) Plesiotype, lower valve, natural size. Upper part of Paskenta group; Loc. 113 (C. A. S.), Hamlin—Broad zone, Cottonwood district, Shasta County. p. 111.

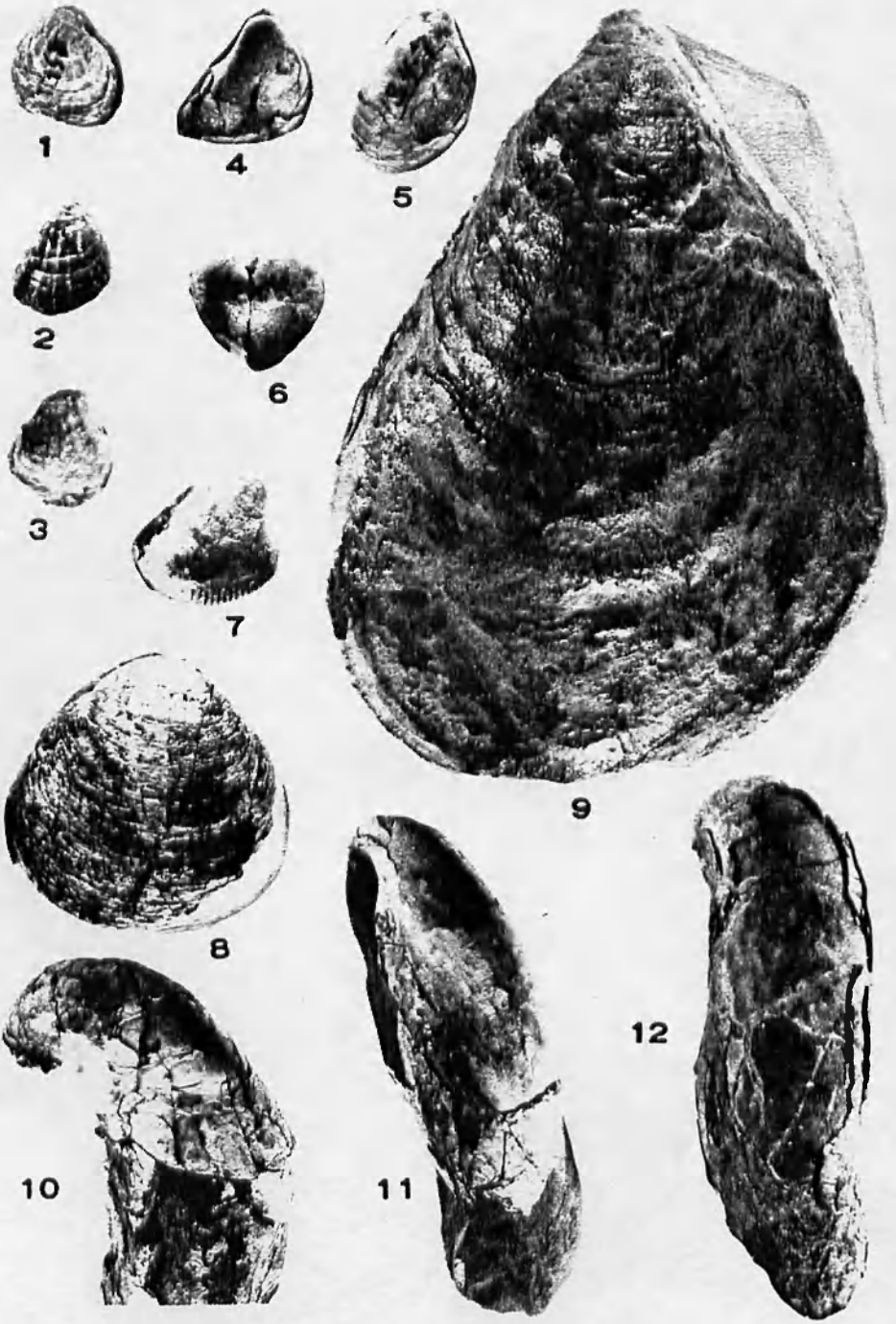
(4, 5) *Opis shastalis* nov. (4) Holotype, right valve, natural size. (5) Plesiotype, natural size. Barr zone, lower part of Horsetown group; Loc. 1347 (C. A. S.), Mitchell Creek, Shasta County. p. 121.

(6, 7) *Venus corelia* nov. Holotype. (6) Front view, enlarged. (7) Right valve, enlarged. Length 11 mm.; height, 12 mm.; thickness, 11 mm. Perrin zone, upper part of Horsetown group; Loc. 1346-A (C. A. S.), Hulen Creek, Shasta County. p. 122.

(8) *Venus collinium* nov. Paratype, right valve, slightly enlarged. Upper part of Paskenta group; Loc. 113 (C. A. S.). p. 122.

(9) *Inoceramus ovatus* Stanton. Example from west border of Berryessa Valley, Napa County. Natural size, Paskenta group. p. 99.

(10-12) *Inoceramus colonicus* nov. Plesiotypes. (10) Right valve (incomplete), natural size; lower part of Horsetown group; Loc. 1353 (C. A. S.), near Ono, Shasta County. (11) Plesiotype, same locality and horizon. (12) Right valve, natural size; Lower part of Horsetown group; "Zone T", McCarthy Creek, Tehama County. p. 100.



CRETACEOUS FOSSILS FROM CALIFORNIA

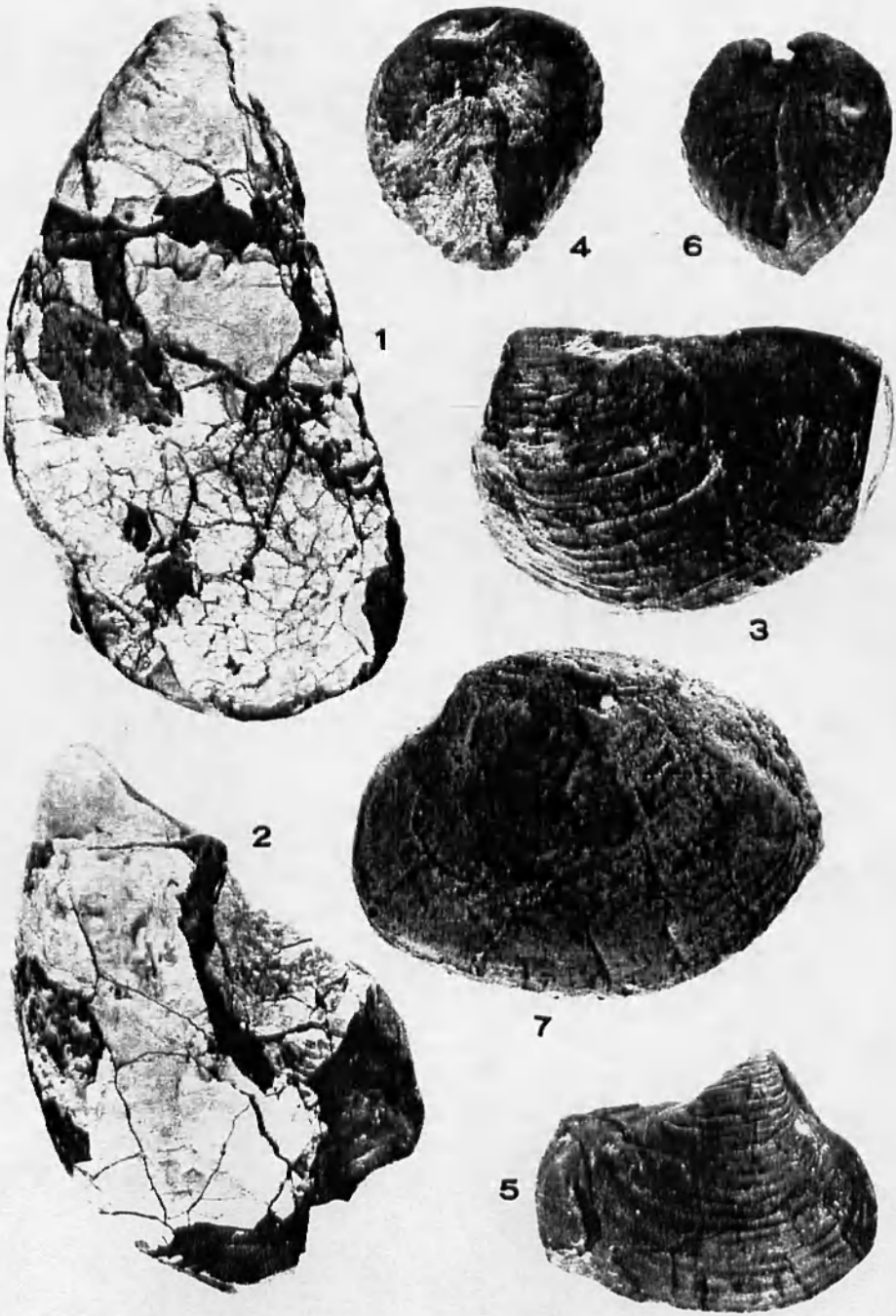
PLATE 5.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1, 2) *Inoceramus colonicus* nov. (1) Holotype, left valve; length, 110 mm.; width, 50 mm. (2) Paratype, left valve, natural size. Lower part of Horsetown group; Loc. 1661 (C. A. S.), Roaring River district, Shasta County. p. 100.

(3, 4) *Pholadomya russelli* nov. Holotype. (3) Left valve; length, 63 mm.; height, 45 mm. (4) Front view of same. Upper part of Horsetown group; Loc. 1659 (C. A. S.), Neptune zone, Hulen Creek. p. 116.

(5, 6) *Pholadomya altumbonata* nov. Holotype, slightly enlarged. (5) Side view; length, 41 mm.; height, 33 mm. (6) Front view of same example. Upper part of Paskenta group; Loc. 1691 (C. A. S.), Clements ranch, Trinity County. p. 116.

(7) *Lucina alcatrazis* nov. Holotype. Plaster cast from rock mold, slightly enlarged. Length 53 mm.; height, 41 mm. Probably Paskenta group; Alcatraz Island, San Francisco Bay, California. p. 121.



CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 6.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1) *Inoceramus vallejoensis* nov. Sketch of holotype. Length, 10 inches; width, 7 inches. Paskenta group; "Cement rock" quarry, Napa Junction, Napa County. p. 100.

(2) *Inoceramus ovatoides* nov. Holotype, left valve; length, 160 mm.; greatest width, 95 mm. Lower part of Horsetown group; Loc. 1347 (C. A. S.), Mitchell Creek, Shasta County. p. 100.

(3) *Inoceramus colonicus* nov. Beak of example from the type locality, Loc. 1353 (C. A. S.), near bridge, Cottonwood Creek, at Onò, Shasta County. Lower part of Horsetown group, Ono zone. p. 100.

CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 7.—CRETACEOUS FOSSILS FROM CALIFORNIA, OREGON, AND BRITISH COLUMBIA

(1) *Inoceramus elliotti* Gabb. Sketch of holotype, showing restored outline. Natural size. Probably Paskenta group; Alcatraz Island, San Francisco Bay, California. p. 99.

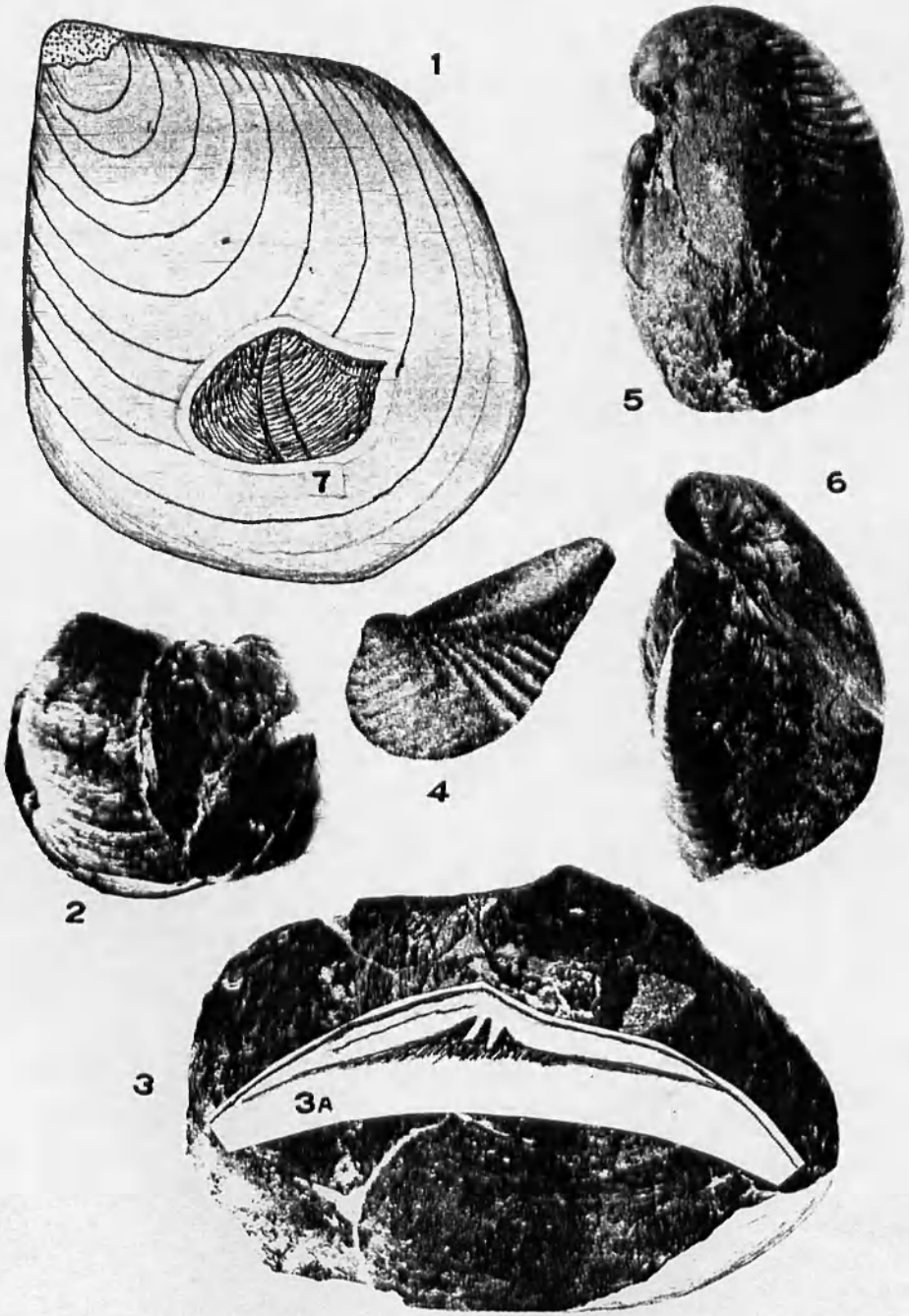
(2) *Clisocolus indubitus* nov. Holotype, enlarged. Left valve; length, 20 mm.; height, 25 mm.; Ono zone, basal beds of Horsetown group; Loc. 1353 (C. A. S.), near Ono, Cottonwood Creek, Shasta County. p. 121.

(3, 3a) *Tellina* (*Arcopagia*) *tehama* nov. Holotype. (3) Left valve; length, 85 mm.; height, 62 mm. (3a) Interior of left valve, showing hinge plate and cardinal teeth. Lower Chico beds; Middle fork of Cottonwood Creek, northern Tehama County. p. 123.

(4) *Trigonia kayana* nov. Holotype. Reproduction of figure by Diller and Kay, enlarged. Paskenta group; Riddle quadrangle, Oregon. p. 108.

(5, 6) *Aucella indigenalis* nov. Holotype. (5) Left valve, natural size. (6) Right valve, and beak of left valve; natural size. Lower Cretaceous beds, Graham Island, British Columbia. p. 107.

(7) *Turnus gregarius* nov. Composite drawing of left valve, ×5. Average length, 5 mm.; height, 3.5 mm. Neptune zone, upper part of Horsetown group, east branch of Hulen Creek, Shasta County. p. 125.



CRETACEOUS FOSSILS FROM CALIFORNIA, OREGON, AND BRITISH COLUMBIA

PLATE 8.—CRETACEOUS FOSSILS FROM CALIFORNIA AND BRITISH COLUMBIA

(1, 2). *Aucella crassicollis* Keyserling. Back and front views of an example from Winslow bridge, Glenn County. Length (incomplete), 55 mm.; greatest width, 40 mm.; thickness, 25 mm. Base of Paskenta group. p. 103.

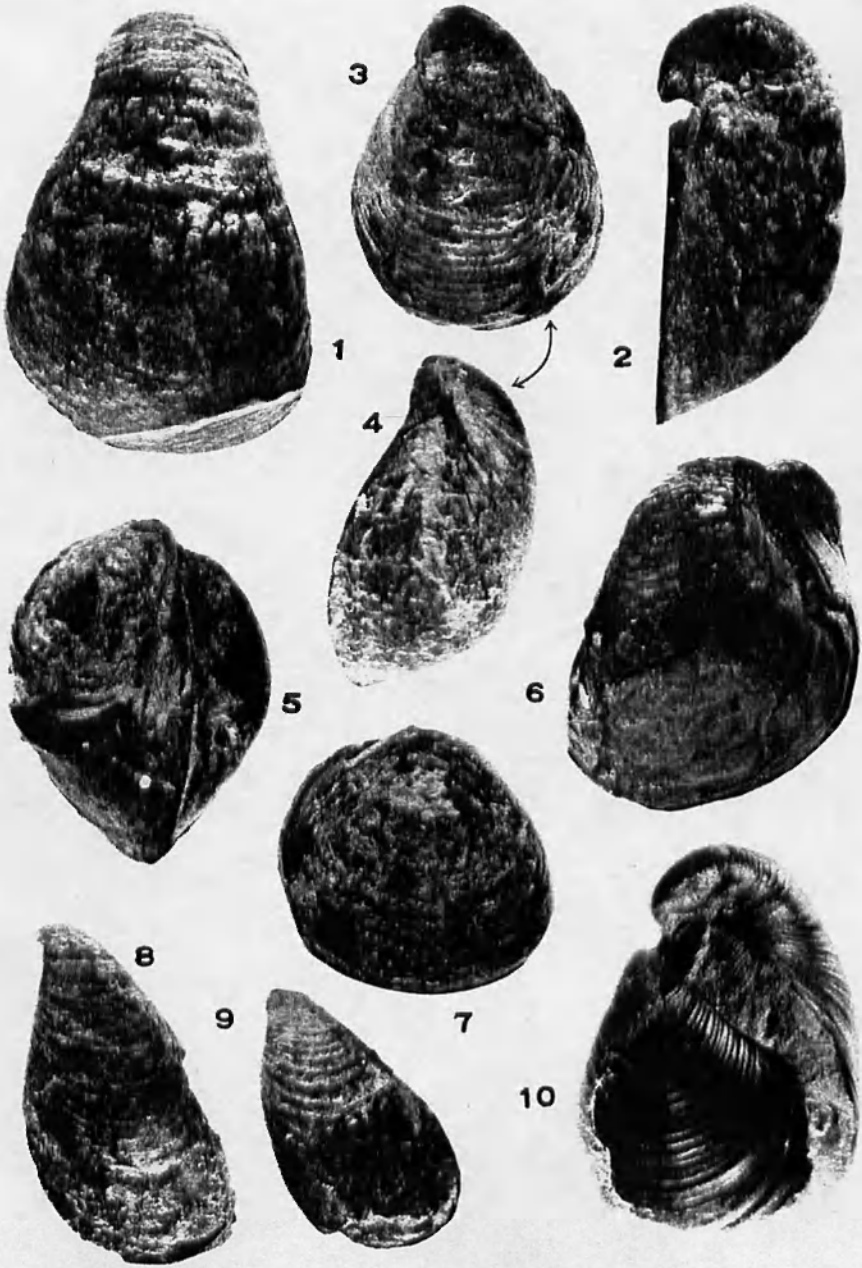
(3, 4) *Aucella piriformis* Lahusen. Back and front views of left valve. Length, 50 mm.; width, 37 mm.; thickness 23 mm. Lower part of Paskenta group; Winslow bridge, Glenn County. p. 105.

(5, 6) *Aucella inflata* Toula. Top and side views of an example from Winslow bridge, Glenn County. Length, 55 mm.; width of left valve, 42 mm.; thickness of both valves, 37 mm. Lower part of Paskenta group. p. 104.

(7) *Aucella crassa* Pavlow. Left valve of an example from "Zone L", McCarthy Creek, Tehama County. Length, 39 mm.; width, 40 mm. Lower part of Paskenta group. p. 103.

(8, 9) *Aucella lahuseni* Pavlow. Examples from Stony Gorge dam, near Elk Creek village, Glenn County. (8) Left valve; length, 47 mm.; width (if complete), 24 mm. (9) Left valve of smaller example. Length, 40 mm.; width, 20 mm. Lower beds of Paskenta group. p. 106.

(10) *Aucella indigenalis* nov. Holotype, showing right valve and upper part of left valve. Length, 55 mm.; width of right valve, 33 mm. Lower Cretaceous beds, Graham Island, British Columbia. p. 107.



CRETACEOUS FOSSILS FROM CALIFORNIA AND BRITISH COLUMBIA

PLATE 9.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1) *Nerinea archimedis* nov. Holotype. Height of spire (incomplete), 51 mm.; width at base, 13 mm. Ono zone, lower part of Horsetown group; Loc. 1353 (C. A. S.), Cottonwood Creek, near Ono, Shasta County. p. 132.

(2, 3) *Nerinea* sp. indet. (2) Exterior of part of spire. (3) Another example, showing interior spire. Lower beds of Horsetown group; Loc. 1353 (C. A. S.), near Ono, Shasta County. p. 133.

(4–6) *Anchura biangulata* nov. (4) Holotype. Height (incomplete), 57 mm.; width of body whorl, 25 mm. (5) Paratype, rear view. (6) Another example, showing front view with triangulate aperture, and spur on outer part of wing. Lower beds of Chico series; Loc. 1346 (C. A. S.), Cottonwood Creek, Shasta County. p. 134.

(7) *Pleurotomaria californica* nov. Holotype. Height of spire, 24 mm.; width of base, 43 mm. Argonaut zone, Horsetown group; Loc. 1348 (C. A. S.), Alderson Creek, Shasta County. p. 126.

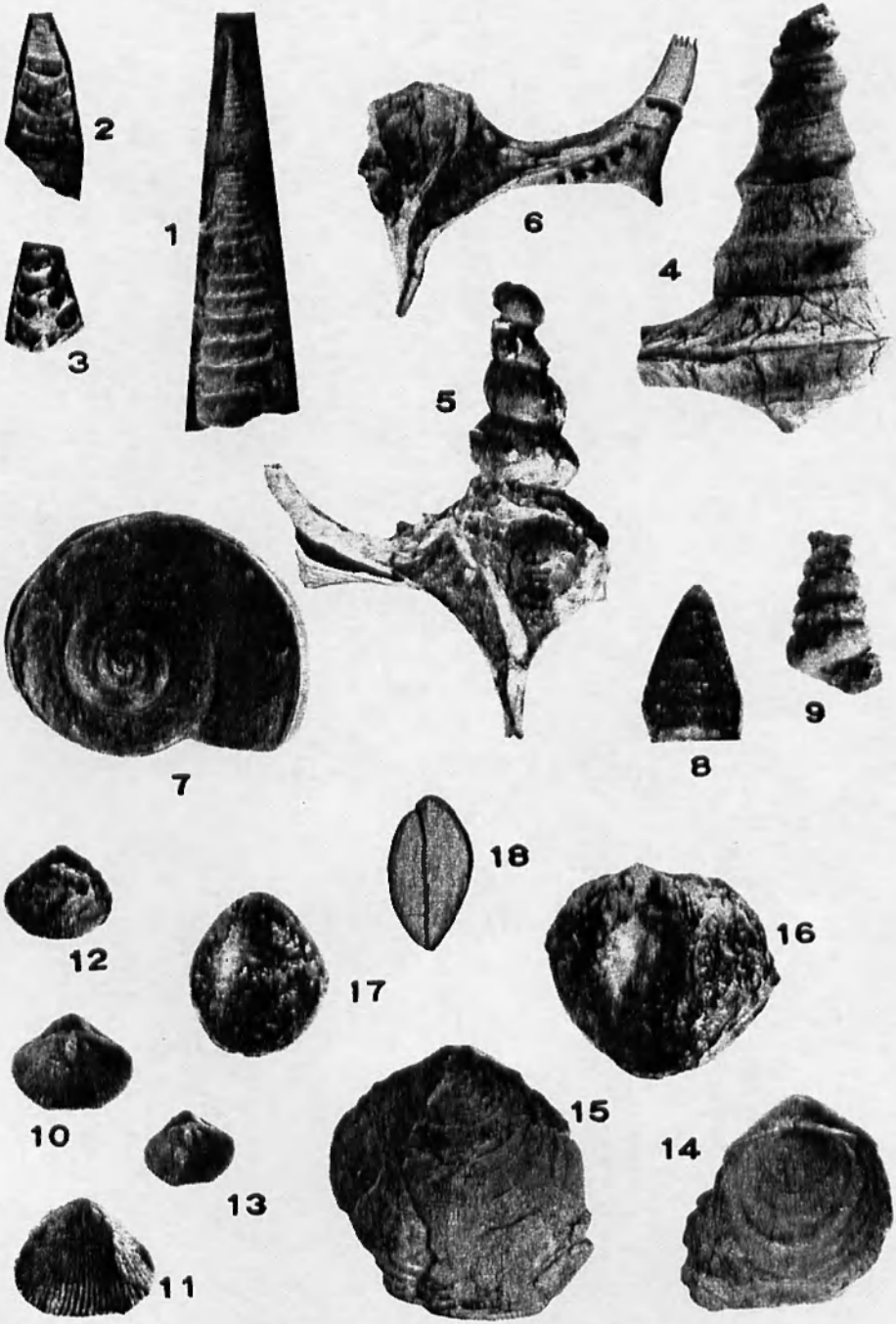
(8, 9) *Glauconia hesperia* nov. Holotype. (8) Wax cast from rock mold. (9) Rock cast of same, shell removed. Ono zone, lower part of Horsetown group; Loc. 1353 (C. A. S.), Cottonwood Creek, Shasta County. p. 132.

(10–13) *Terebratella averilli* nov. (10) Holotype. Length, 14 mm.; width, 16 mm. (11) Paratype. Length, 16 mm.; width, 18 mm. (12, 13) Other examples of same. Lower part of Horsetown group; Barr zone, Loc. 1347 (C. A. S.), Mitchell Creek.

(14, 15) *Terebratula hannana* nov. (14) Holotype, upper valve; length (incomplete), 22 mm.; width, 24 mm. Length of lower valve (incomplete), 30 mm. (15) Paratype, lower valve; length, 38 mm.; width, 35 mm. "Zone U", McCarthy Creek, Tehama County. p. 95.

(16) *Terebratula durrelli* nov. Holotype, enlarged. Length of lower (ventral) valve, 25 mm.; width, 28 mm. Lower part of Horsetown group, Fiddler Creek, 10 miles south of Ono, Shasta County. p. 95.

(17, 18) *Terebratella ovula* nov. Holotype. (17) Ventral valve; length, 20 mm.; width, 16 mm. Neptune zone, upper part of Horsetown group. Loc. 1659 (C. A. S.), east branch of Hulen Creek, Shasta County. (18) Drawing showing thickness of both valves. p. 94.



CRETACEOUS FOSSILS FROM CALIFORNIA

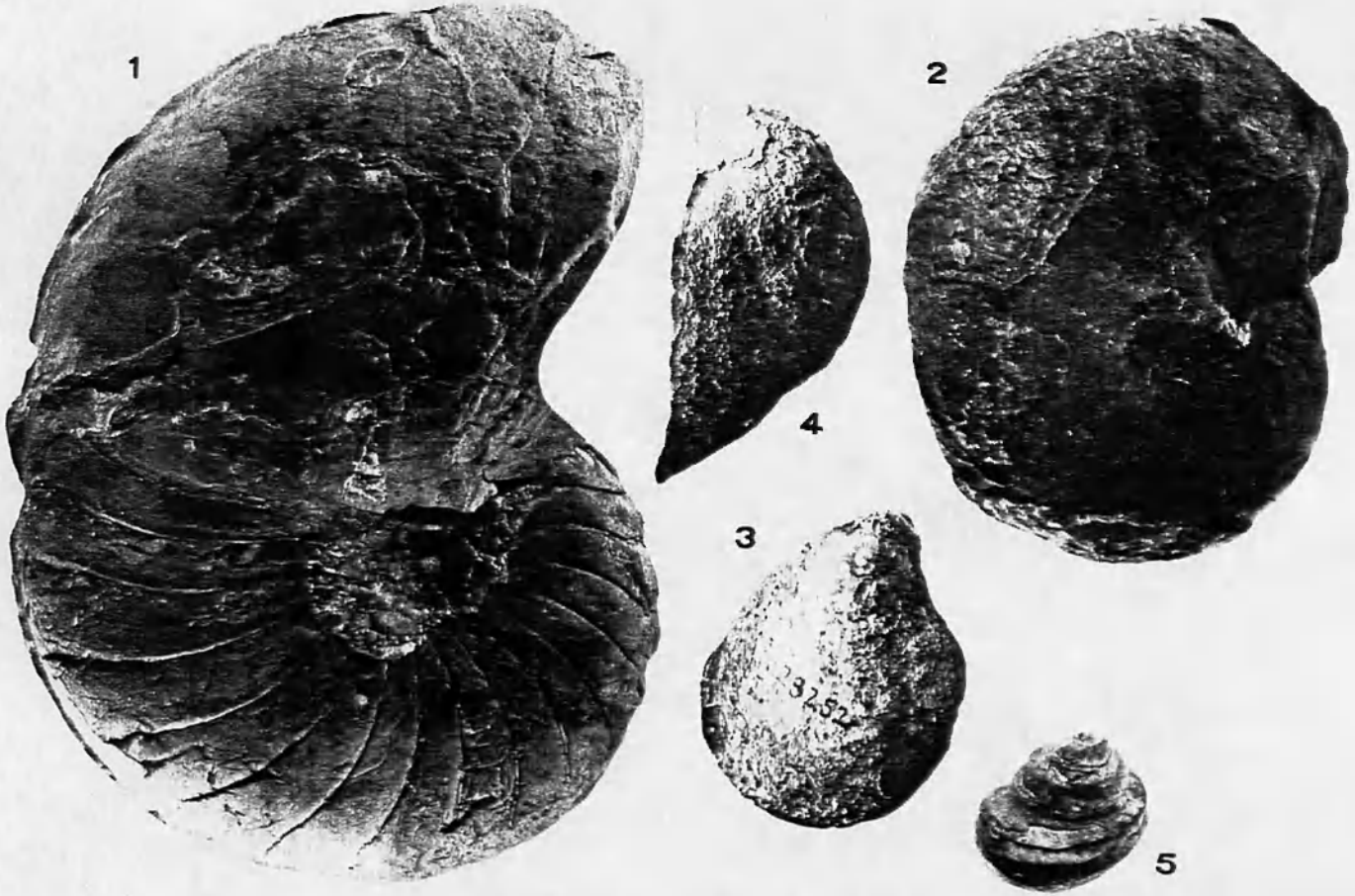
PLATE 10.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1) *Nautilus gabbi* Anderson. A large example found in the Perrin zone on the east branch of Hulen Creek, Shasta County. Figure reduced; greatest diameter, 150 mm.; thickness of whorl, 70 mm. Loc. 1668 (C. A. S.). p. 138.

(2) *Nautilus averilli* nov. Holotype. Greatest diameter, 72 mm.; thickness of whorl, 48 mm. Barr zone, middle part of Horsetown group; Loc. 1347 (C. A. S.), Mitchell Creek, Shasta County. p. 139.

(3, 4) *Aucella solida* Lahusen. Reproduction of figures by Pavlow (1907, pl. 3, figs. 25, 26), Shelton's ranch, Tehama County. "Zone M_1", Paskenta group, McCarthy Creek section. p. 105.

(5) *Turbo festivus* nov. Holotype. Height of spire, 25 mm.; width at base, 17 mm. Ono zone, Loc. 1353 (C. A. S.), near Ono, Cottonwood Creek, Shasta County, lower beds of Horsetown group. p. 129.

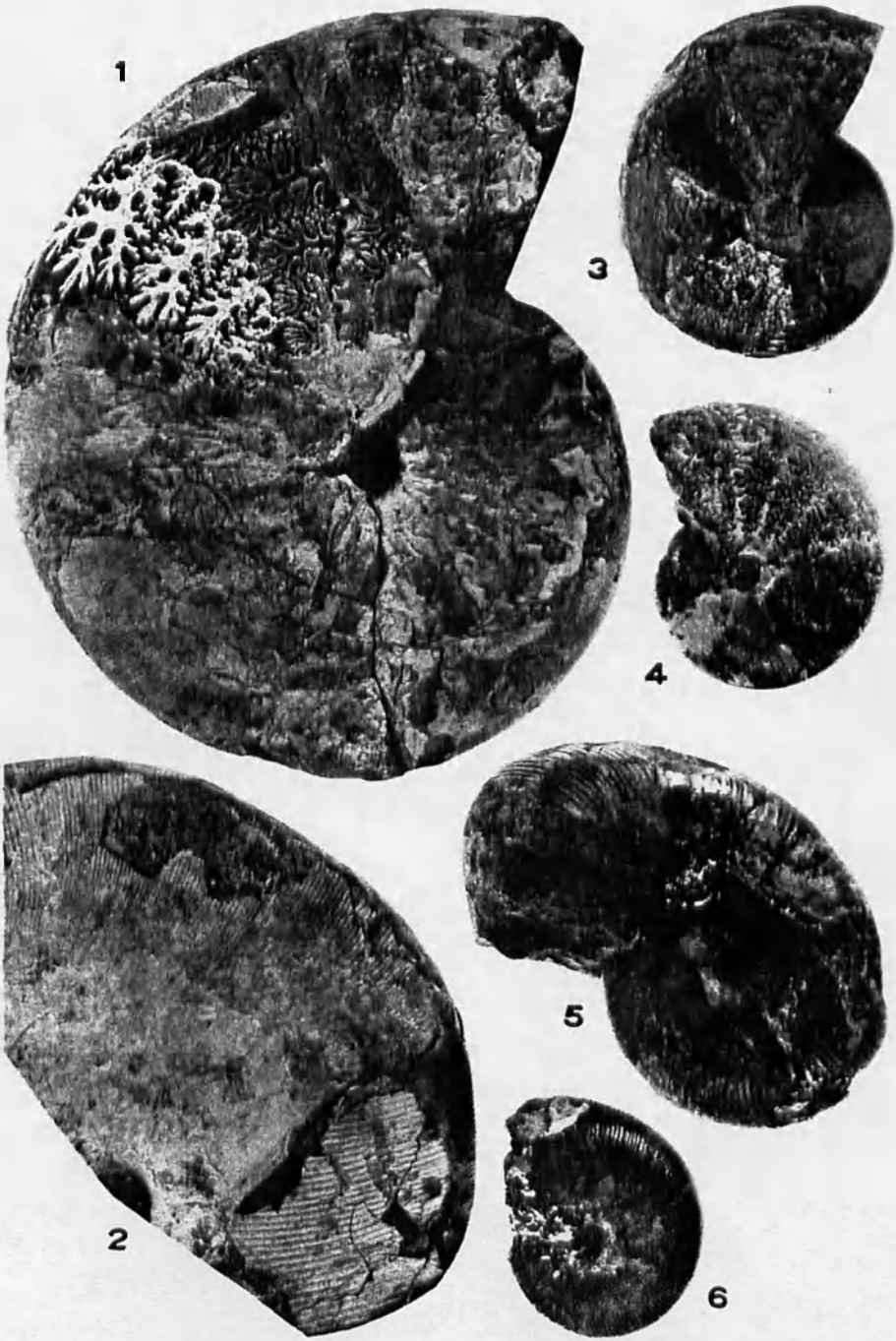


CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 11.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1, 2) *Phylloceras onoense* Stanton. (1) Lectotype. Greatest diameter, 120 mm.; thickness of whorl, 55 mm. Argonaut zone, middle of Horsetown group; Loc. 1347 (C. A. S.), Mitchell Creek, Shasta County. (2) Fragment of another example with portion of shell, showing sculpture. p. 142.

(3–8) *Phylloceras aldersoni* nov. (3) Holotype. Greatest diameter, 40 mm.; thickness of whorl, 17 mm. Argonaut zone, middle of Horsetown group; Loc. 1348 (C. A. S.), Alderson Creek, 2 miles south of Ono, Shasta County. (4) Paratype. Same locality and horizon. (5, 6) Plesiotypes, showing sculpture of shell; same locality and horizon. p. 143.



CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 12.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1, 2) *Phylloceras occidentale* nov. (1) Holotype. Greatest diameter, 48 mm.; thickness of whorl, 23.5 mm. Near Barr zone, middle of Horsetown group; Loc. 1347 (C. A. S.), east of Mitchell Creek, 5 miles south of Ono, Shasta County. (2) Paratype. Fragment showing only outer portion of whorl, without umbilical pit. Ono zone, lower part of Horsetown group, near Ono. p. 139.

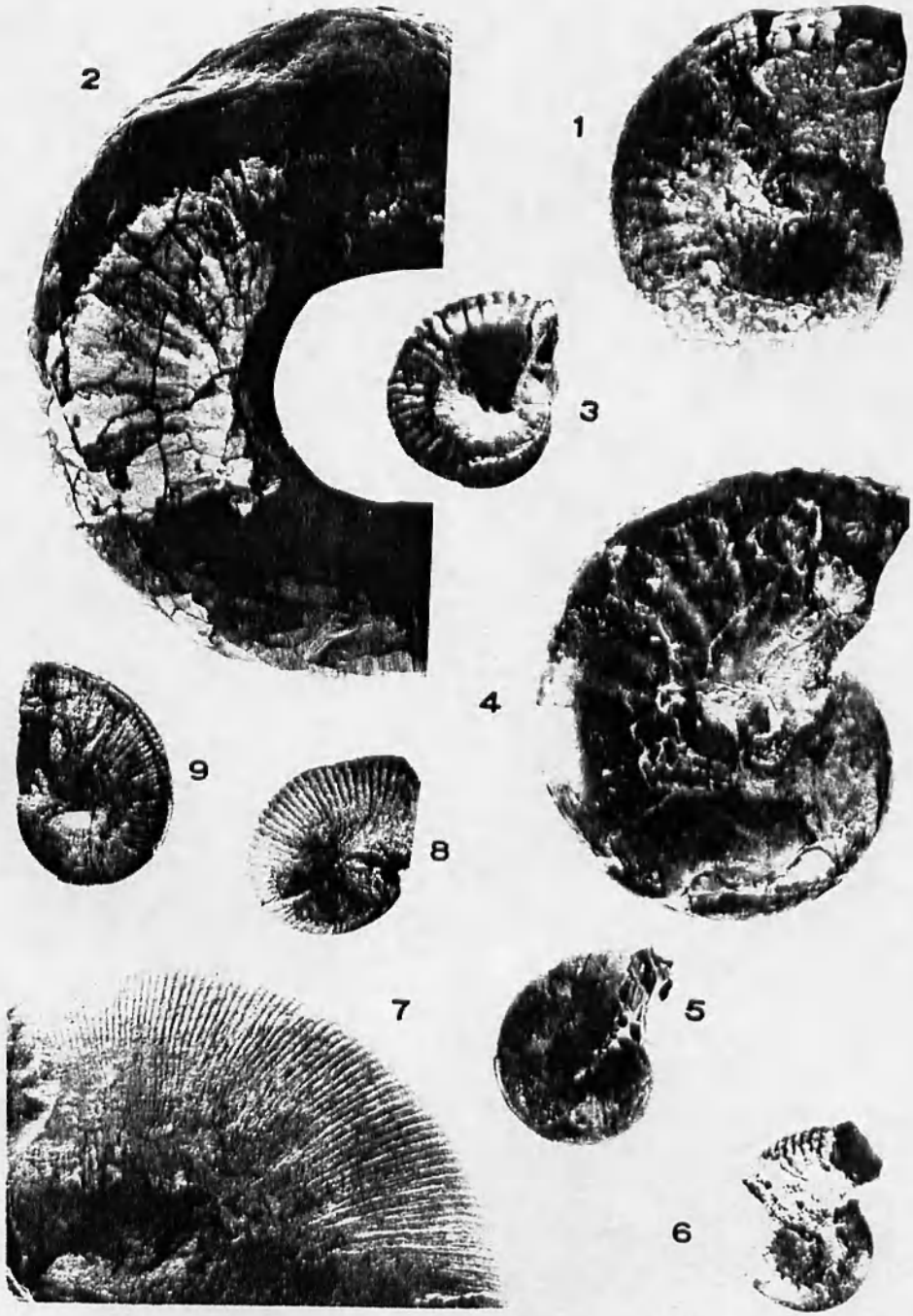
(3) *Phylloceras sextoni* nov. Holotype. Greatest diameter, 27 mm.; thickness of whorl, 14 mm. Mitchell zone, lower part of Horsetown group; near Jordan gate, 5 miles south of Ono, Shasta County. p. 140.

(4, 5) *Phylloceras theresae* nov. (4) Holotype. Greatest diameter, 65 mm.; thickness of whorl, 32 mm. Perrin zone, upper part of Horsetown group; Loc. 1668 (C. A. S.), east branch of Hulen Creek, Shasta County. (5) Paratype. Greatest diameter, 30 mm.; Perrin zone; Loc. 152 (C. A. S.), east branch of Hulen Creek, Shasta County. p. 141.

(6) *Phylloceras shastalense* Anderson. Topotype. Greatest diameter, 25 mm. Loc. 1344 (C. A. S.), old Horsetown, upper part of Horsetown group, Shasta County. p. 141.

(7) *Phylloceras californicum* nov. Holotype. Large fragment of whorl, much reduced. Greatest diameter (est.), 203 mm.; Neptune zone, upper part of Horsetown group; Loc. 1569 (C. A. S.), east branch of Hulen Creek, Shasta County. p. 143.

(8, 9) *Phylloceras* cf. *oregonense* nov. (8) Example from Ono zone, lower beds of Horsetown group; Eagle Creek, near Ono, Shasta County. Natural size. p. 144; (9) Example from Ono zone, Eagle Creek, near Ono, Shasta County. p. 144.



CRETACEOUS FOSSILS FROM CALIFORNIA

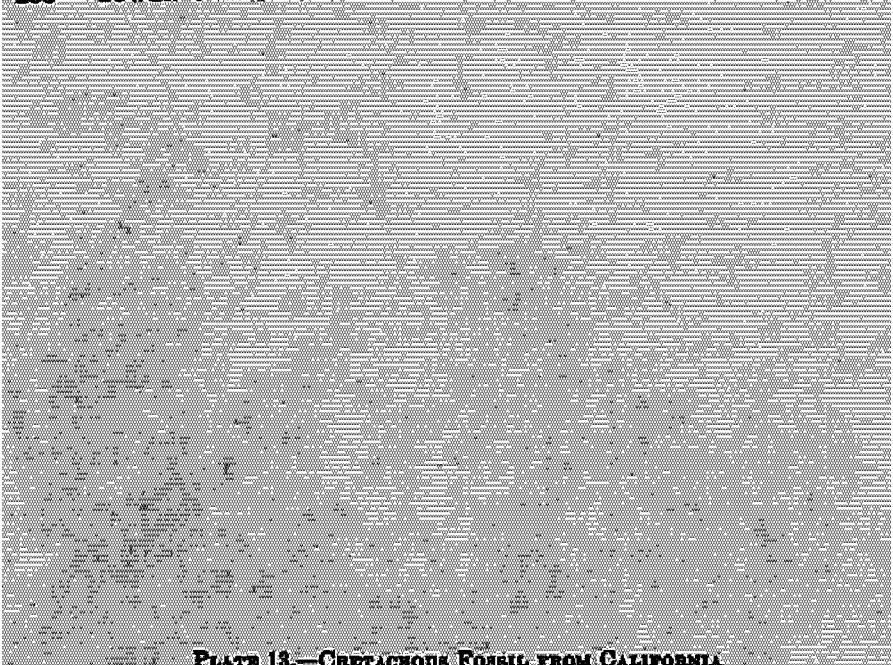
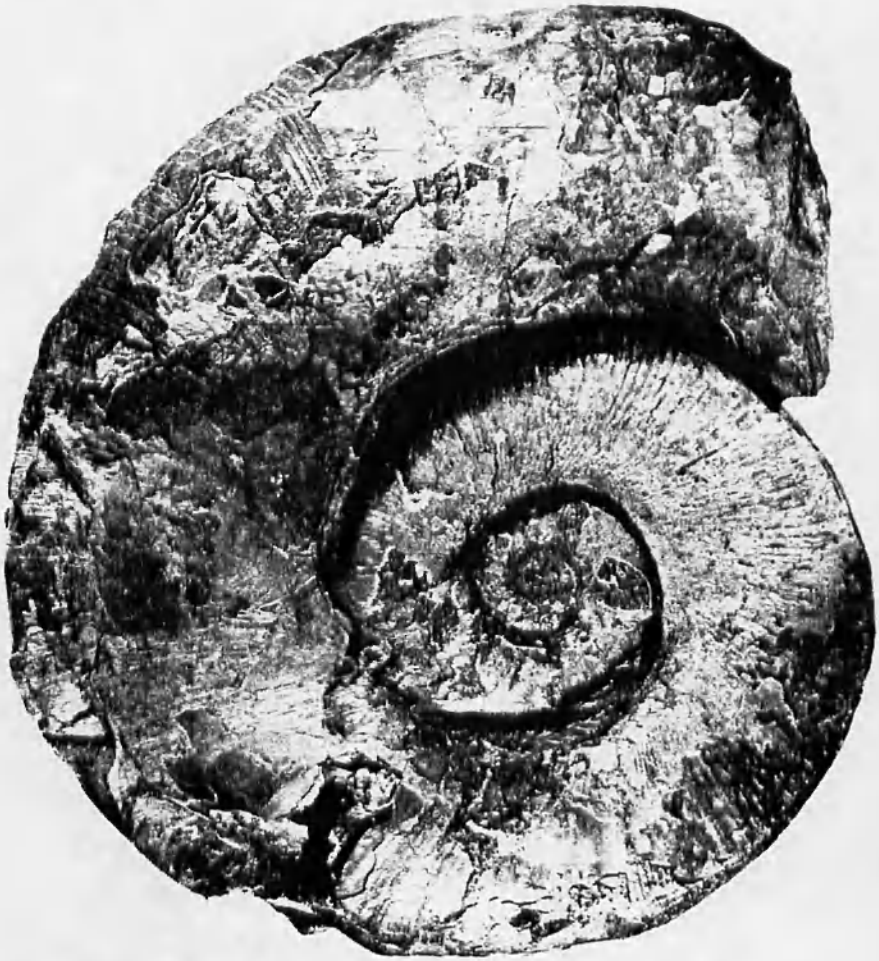


PLATE 13.—CRETACEOUS FOSSIL FROM CALIFORNIA

Lytoceras (*Saturnoceras*) *saturnale* nov. Greatest diameter, 16.5 inches (419 mm.); thickness of whorl, 6 inches (152.4 mm.). Probably from upper part of Paskenta group, Cottonwood Creek, Shasta County. p. 145.



CRETACEOUS FOSSIL FROM CALIFORNIA

PLATE 14.—CRETACEOUS FOSSIL FROM CALIFORNIA

Lytoceras aulasum nov. (1) Holotype. Greatest diameter, 237.5 mm.; greatest thickness of whorl, 61.5 mm. Upper part of Paskenta group; Loc. 113 (C. A. S.), Hamlin—Broad zone, 4 miles southwest of Ono, Shasta County. (2) Fragment of shell showing sculpture of mature shell. Lower part of Horsetown group, near Ono, Shasta County. (3) Fragment of shell showing peristome, side view. (4) Mirror reflection of Fig. 3, showing front of peristome. Lower part of Horsetown group, near Ono, Shasta County. p. 146.

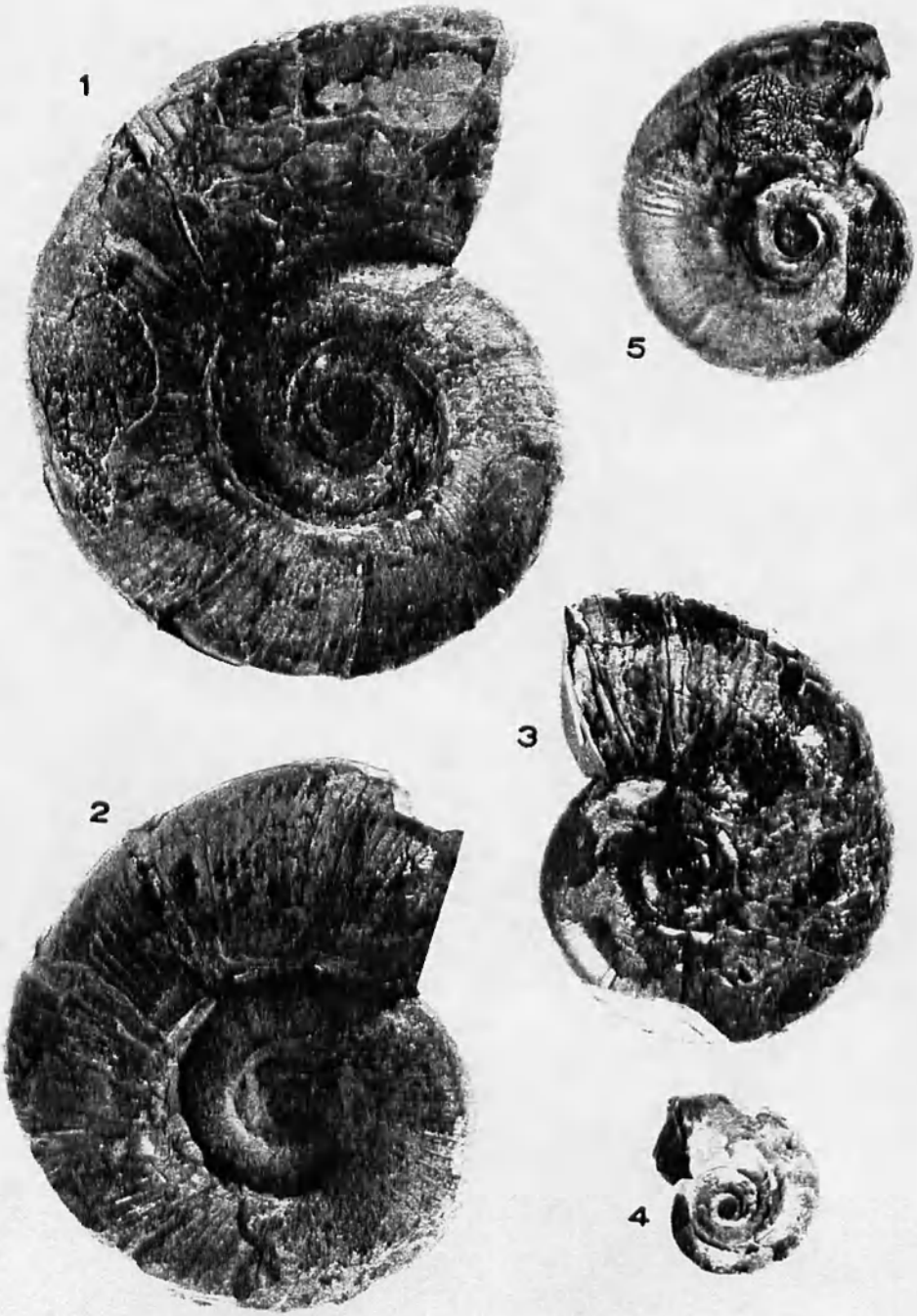
CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 15.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1, 2) *Lytoceras traski* nov. (1) Holotype. Greatest diameter, 125 mm.; thickness of whorl, 43 mm. Lower part of Horsetown group; Loc. 1347 (C. A. S.), Argonaut zone, east of Mitchell Creek, 5 miles south of Ono, Shasta County. (2) *Lytoceras traski* nov. Paratype. Greatest diameter, 78 mm.; same locality and horizon; middle part of Horsetown group, as above. p. 146.

(3, 4) *Lytoceras* (*Gabbioceras*) *angulatum* Andersen. Plesiotype. (3) Mature example; greatest diameter, 65 mm. Argonaut zone, middle of Horsetown group; Loc. 1347 (C. A. S.), 5 miles south of Ono. (4) Young example; diameter 28 mm.; same locality; Shasta County. p. 150.

(5) *Lytoceras* (*Gabbioceras*) *wintunium* nov. Holotype. Greatest diameter, 57 mm.; thickness of whorl, 24 mm. Argonaut zone, middle part of Horsetown group; Loc. 1347 (C. A. S.), east of Mitchell Creek, 5 miles south of Ono, Shasta County. p. 150.



CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 16.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1) *Lytoceras batesi* (Trask). Plesiotype. Well-preserved example from the Academy of Natural Sciences, Philadelphia. Greatest diameter, 134 mm.; probably found in Argonaut zone, Cottonwood district, Shasta County. p. 147.

(2–5) *Lytoceras* (*Gabbioceras*) *twintunium* nov. (2) Holotype. Greatest diameter, 58 mm.; thickness of whorl, 25 mm. (3) Paratype. Greatest diameter, 40 mm.; thickness of whorl, 17 mm. Argonaut zone, middle of Horsetown group; Loc. 1348 (C. A. S.), Alderson Creek, 2 miles south of Ono, Shasta County. (4, 5) Plesiotypes; showing form of umbilical pit. Argonaut zone; Loc. 1347 (C. A. S.), east of Mitchell Creek, 5 miles south of Ono, Shasta County. p. 150.

CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 17.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1) *Lytoceras batesi* (Trask). Lectotype. Greatest diameter, 165 mm.; thickness of whorl, 51.5 mm. Argonaut zone, middle part of Horsetown group; Loc. 1347 (C. A. S.), east of Mitchell Creek, near Roaring River, Shasta County. p. 147.

(2) *Lytoceras traski* nov. Plesiotype; showing form and sculpture of inner whorls; diameter, 50 mm. Argonaut zone; Loc. 1347 (C. A. S.), east of Mitchell Creek, Shasta County. p. 146.

(3) *Lytoceras* (*Argonauticeras*) *argonautarum* Anderson. Young shell, diameter, 77 mm. Argonaut zone; Loc. 1348 (C. A. S.), Alderson Creek, 2 miles south of Ono, Shasta County. p. 149.

CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 18.—CRETACEOUS FOSSIL FROM CALIFORNIA

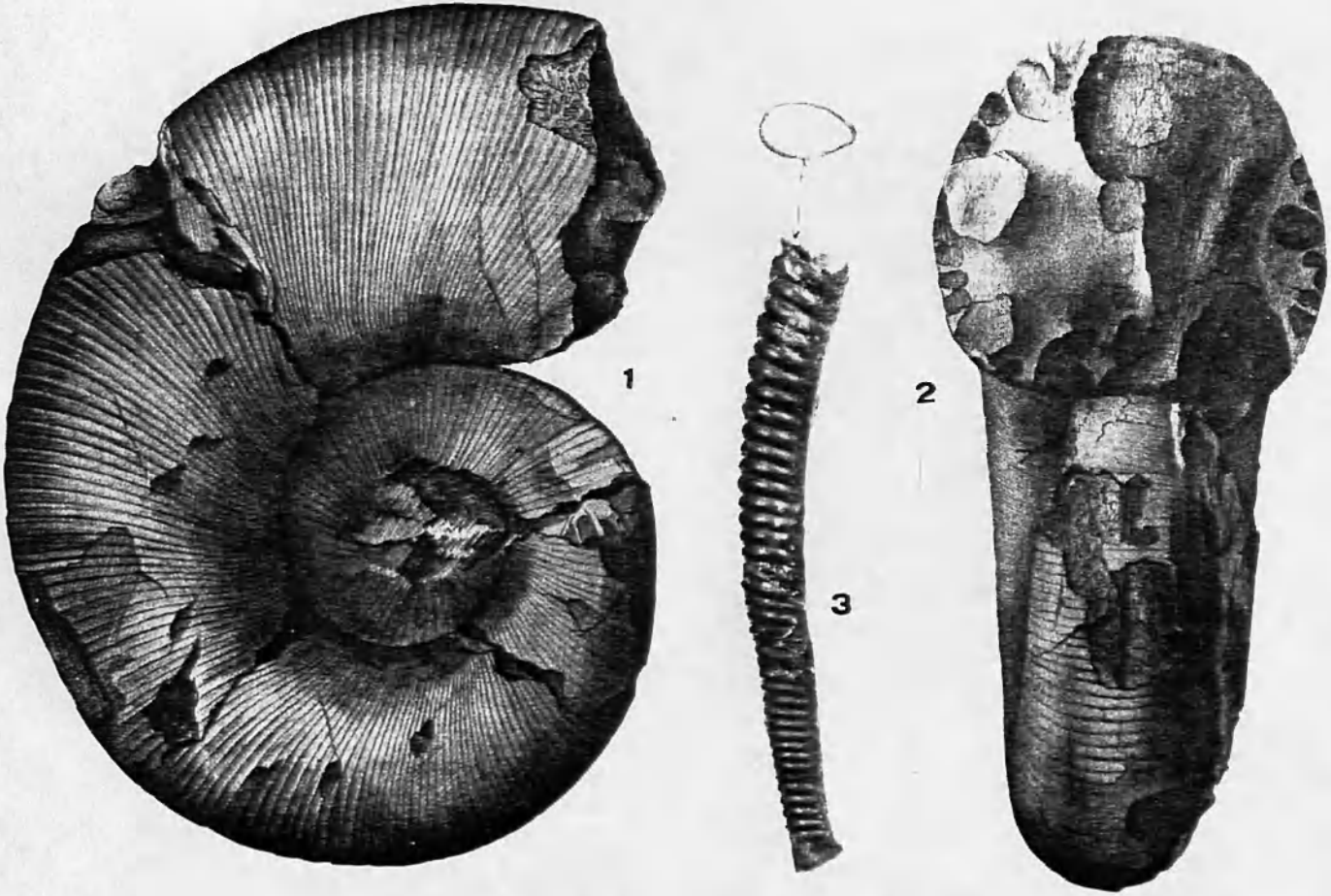
Lytoceras (? *Gaudryceras*) *neptunium* nov. Holotype. Greatest diameter (incomplete), 16.5 inches (420 mm.). Neptune zone, upper part of Horsetown group; Loc. 1650 (C. A. S.), east branch of Hulen Creek, Shasta County. p. 152.

CRETACEOUS FOSSIL FROM CALIFORNIA

PLATE 19.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1, 2) *Lytoceras* (*Argonauticeras*) *argonautarum* (Anderson). Holotype. Copies of original figures. (1) Side view. Greatest diameter, 171 mm.; greatest thickness, 85 mm. Museum of Paleontology, Stanford University, California. Found in the Argonaut zone, 1½ miles east of Ono, Hulen Creek, Shasta County. p. 149.

(3) *Toxoceras cornucapri* nov. Holotype. Length, 67 mm.; transverse diameter, 7 mm. Aldersin Creek, 2 miles south of Ono, Shasta County. Found a little below the Argonaut zone, by W. P. Popenoe and D. W. Scharf, California Institute of Technology. p. 217.



CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 20.—CRETACEOUS FOSSILS FROM CALIFORNIA

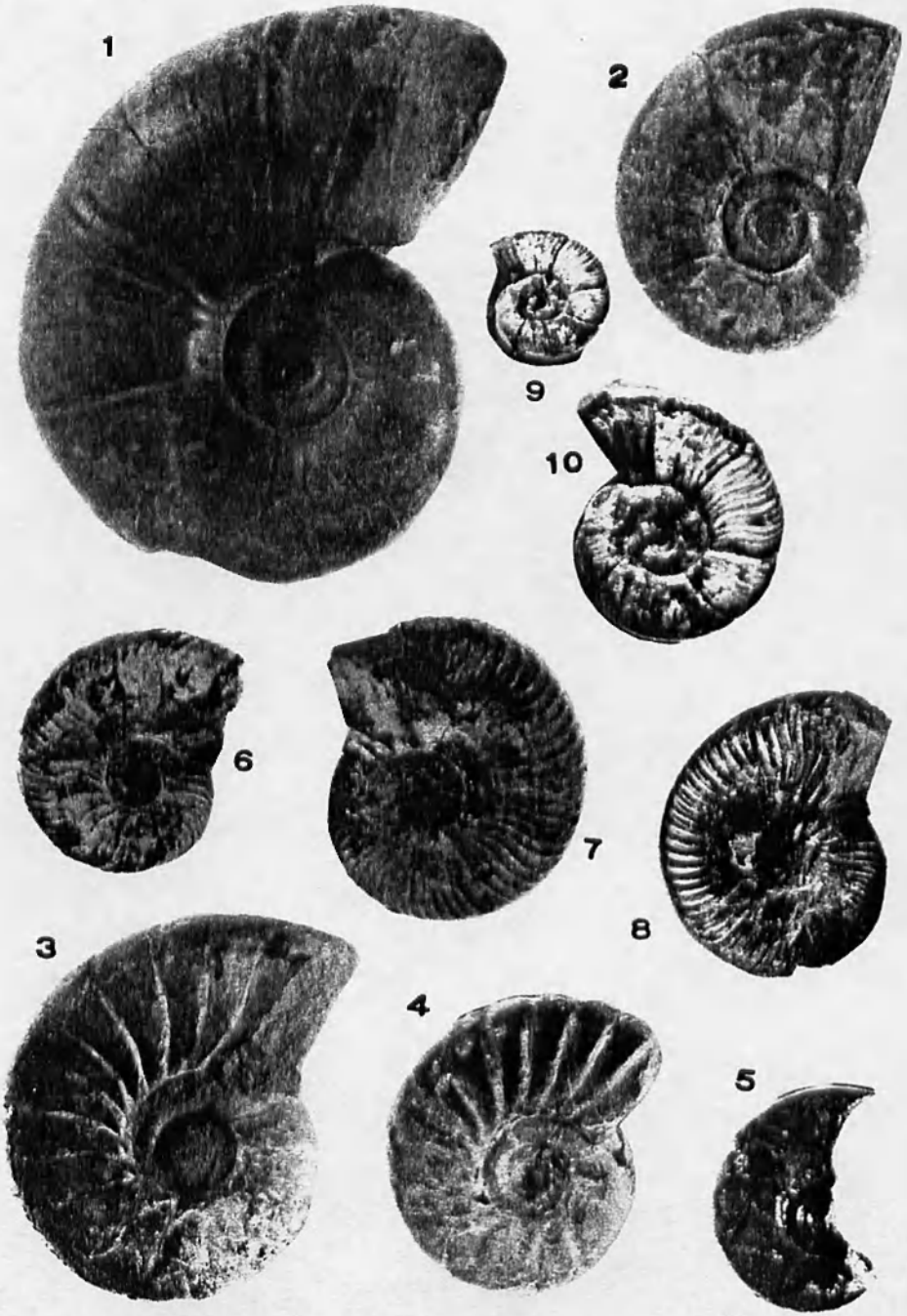
(1, 2) *Lytoceras* (*Kossmatella*) *aurarium* nov. (1) Holotype. Greatest diameter, 83 mm.; greatest thickness, 30 mm. (2) Young adult shell of same. Neptune zone, upper part of Horsetown group; Loc. 1659 (C. A. S.), east branch of Hulen Creek, Shasta County. p. 151.

(3–5) *Lytoceras* (*Kossmatella*) *gainesi* nov. (3) Holotype. Greatest diameter, 58 mm.; greatest thickness, 22 mm. (4) Paratype. Young adult example; greatest diameter, 42 mm. (5) Young Example; diameter, 30 mm. Neptune zone, upper part of Horsetown group; Loc. 1659 (C. A. S.), east branch of Hulen Creek, Shasta County. p. 153.

(6, 7) *Sonneratia rogersi* Hall and Ambrose. Examples from Perrin zone, upper part of Horsetown group; Loc. 152 (C. A. S.), east branch of Hulen Creek, Shasta County. (6) Young example; greatest diameter, 34 mm.; thickness of whorl, 11 mm. (7) Mature example; greatest diameter, 41 mm.; thickness of whorl, 14 mm. p. 197.

(8) *Cleoniceras* cf. *lecontei* (Anderson). Greatest diameter, 38 mm.; thickness of whorl, 13 mm. Perrin zone, upper part of Horsetown group; Loc. 152 (C. A. S.), east branch of Hulen Creek, Shasta County. p. 192.

(9, 10) *Silesites puzosiaformis* nov. (9) Holotype; mature example; greatest diameter, 22 mm.; thickness of whorl, 5.5 mm. Buenavantura zone, upper part of Horsetown group; Loc. 1346-A (C. A. S.), west branch of Hulen Creek, Shasta County. (10) Same example enlarged. p. 191.



CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 21.—CRETACEOUS FOSSILS

(1, 2) *Lytoceras* (*Kossmatella*) *whitneyi* (Gabb). Holotype, front and side views. Greatest diameter, 108 mm.; thickness of whorl, 39 mm. Probably found near Perrin zone, upper part of Horsetown group; definite locality not known. The holotype is in the collections of the Academy of Natural Sciences of Philade'phia. p. 152.

(3) *Hamites imitator* nov. Holotype, ventro-lateral view. Length, 67 mm.; ventro-dorsal diameter, 44 mm. Perrin zone, upper part of Horsetown group; Loc. 1668 (C. A. S.), east branch of Hulen Creek, Shasta County. (3a) Cross section of holotype. p. 218.

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3-A

2

CRETACEOUS FOSSILS

PLATE 22.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1) *Polyptychites leconteï* nov. Holotype. Greatest diameter, 165 mm.; thickness of whorl, 62 mm. Hamlin—Broad zone, upper part of Paskenta group; Loc. 113 (C. A. S.), 4 miles southwest of Ono, Shasta County. p. 154.

(2, 3) *Simbirskites broadi* nov. Holotype. (2) Left side view, showing umbilicus and character of ribbing. (3) Right side of same, from plaster cast of partial rock mold. Loc. 113 (C. A. S.), Hamlin—Broad zone, upper part of Paskenta group, 4 miles southwest of Ono, Shasta County. p. 155.

(4, 5) *Subastieria chanchetula* nov. (4) Holotype, fragmentary example; greatest diameter, 22 mm. (est.); height of whorl, 10 mm.; thickness of whorl, 12 mm. (5) Plaster cast from a rock mold of same example. Hamlin—Broad zone, upper part of Paskenta group; Loc. 113 (C. A. S.), 4 miles southwest of Ono, Shasta County. p. 156.

CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 23.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1) *Polyptychites leconteï* nov. Paratype. Greatest diameter, 191 mm.; thickness of whorl, 64 mm. Hamlin—Broad zone, upper part of Paskenta group; Loc. 113 (C. A. S.), 4 miles southwest of Ono, Shasta County. p. 154.

(2) *Neocraspedites rectoris* nov. Holotype. Greatest diameter, 53 mm.; thickness of whorl, 26 mm. Lower beds of the Horsetown group; Ono zone; Loc. 1353 (C. A. S.), near bridge at Ono, Shasta County. p. 157.

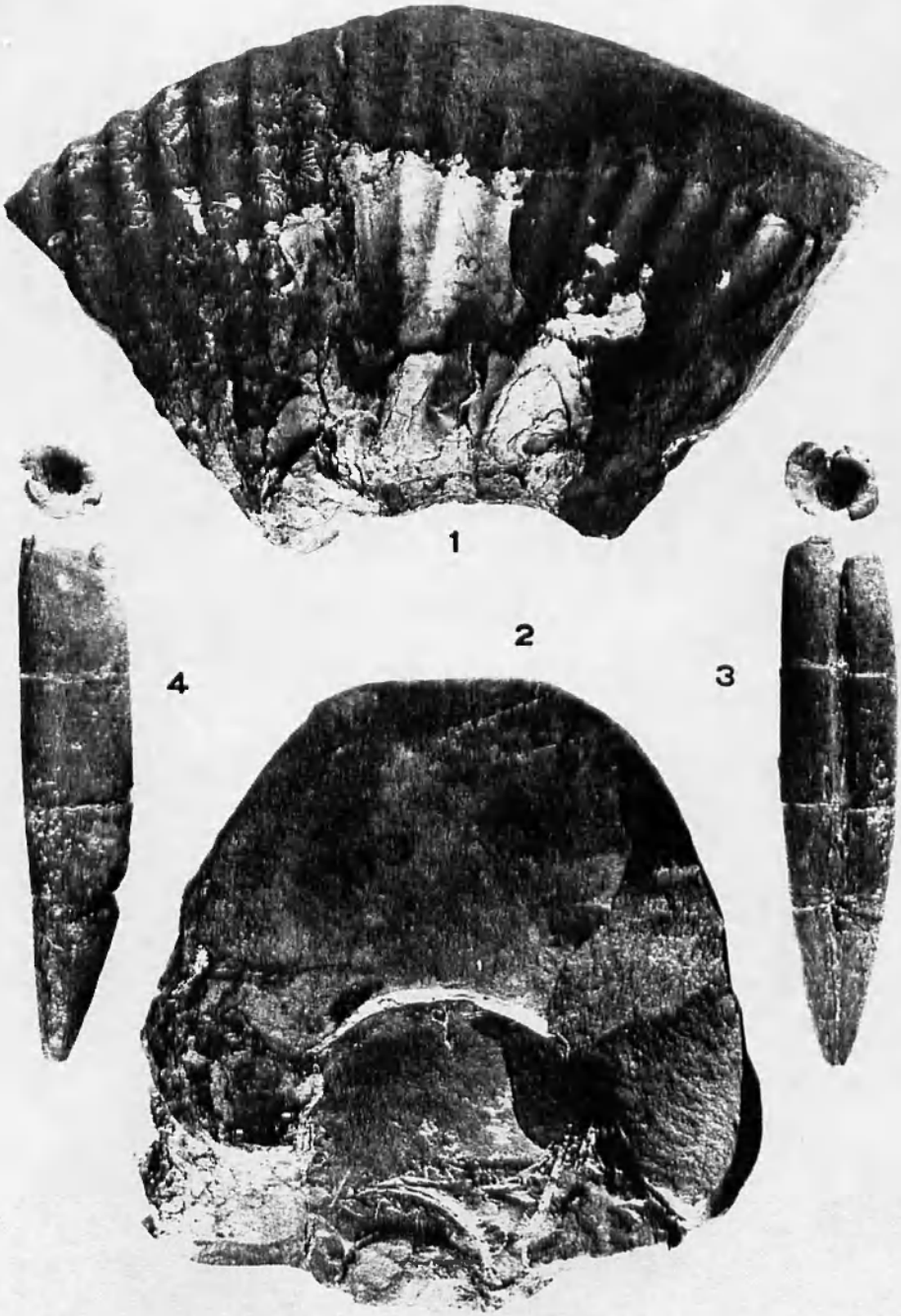
(3, 3a) *Anahamulina vespertina* nov. Holotype. Width of body-chamber, across both limbs, 61 mm.; dorso-ventral diameter, of larger limb, 21 mm.; diameter of smaller limb, 18 mm. Hamlin—Broad zone, upper part of Paskenta group; Loc. 113 (C. A. S.), 4 miles southwest of Ono, Shasta County. (3a) Section of Bucal end of holotype. p. 219.

CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 24.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1, 2) *Polyptychites hesperius* nov. Holotype. Fragment of whorl. (1) Right side; greatest length, 180 mm. (2) End view of same, showing section of whorl; greatest width, 105 mm.; height of whorl, 97 mm. Hamlin—Broad zone, upper part of Paskenta group; Loc. 113 (C. A. S.), 4 miles southwest of Ono, Shasta County. p. 154.

(3, 4) *Aeroteuthis kewana* nov. Holotype. Ventral and side views, with mirror reflections, showing end (cross-section). Length of holotype, 93 mm.; greatest diameter, 21 mm. Paskenta group; 3.3 miles southwest of Lompoc, Santa Barbara County. p. 227.



CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 25.—CRETACEOUS FOSSIL FROM CALIFORNIA

Neocrospedites aquila nov. (1) Side view; plaster cast made from rock mold of holotype. (2) Fragment of holotype, showing part of the suture line. Greatest diameter of holotype, 185 mm. (est.); thickness of whorl, 60 mm. In Ono zone, lowest beds of the Horsetown group; Loc. 1353 (C. A. S.), near bridge at Ono, Shasta County. (3) Paratype. Greatest diameter, 203 mm.; thickness of whorl, 65.8 mm. Same locality as the holotype. p. 156.

CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 26.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1) *Neocrospedites signalis* nov. Holotype. Greatest diameter, 143 mm.; thickness of whorl, 36 mm. Lower part of Horsetown Group; found on the Wilcox ranch, 5 miles north of Paskenta, Tehama County. p. 157.

(2) *Neocrospedites wilcoxi* nov. Holotype. Greatest diameter (est.), 138 mm.; thickness of whorl, 43 mm. Lower part of Horsetown Group; found on the Wilcox ranch, 5 miles north of Paskenta, Tehama County. p. 158.

(3) *Cheloniceras fenoyi*. nov. Fragment of holotype, reduced, showing right side; length, 98 mm.; greatest height of whorl, 45 mm. Lower part of Horsetown Group; "Zone U"; near Paskenta—Lowry road, Tehama County. p. 179.

CRETACEOUS FOSSILS FROM CALIFORNIA

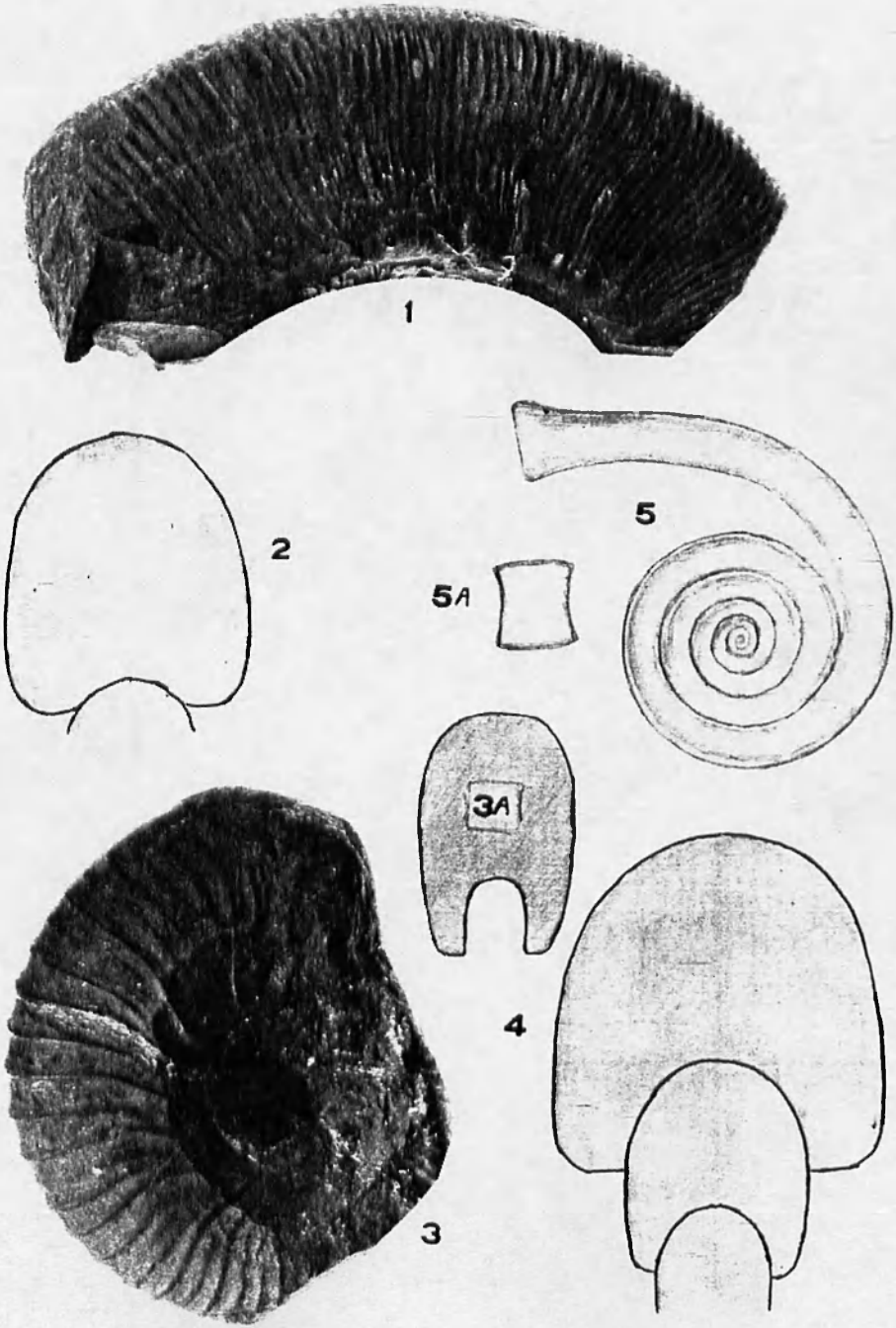
PLATE 27.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1, 2) *Spiticeras duncanense* nov. Holotype. A fragment of the outer, nonseptate part of the coil. Greatest diameter (est.), 147 mm.; height of whorl, 33 mm.; width of whorl, 33 mm. Middle part of Paskenta Group; Loc. 1665 (C. A. S.), Duncan Creek, Shasta County. (2) Transverse section of holotype. p. 160.

(3, 3a) *Neocomites russelli* nov. Holotype. Greatest diameter, 73 mm.; thickness of whorl, 20 mm.; height of whorl, 37 mm. Middle part of Paskenta Group; Loc. 1665 (C. A. S.), Duncan Creek, Shasta County. (3a) Section of outer whorl, slightly reduced. p. 165.

(4) Section of *Neocraspedites wilcoxi* nov., holotype; Wilcox ranch, Tehama County. p. 158.

(5, 5a) *Discohelix planigyroides* Hanna nov. Drawing of holotype, much enlarged. Greatest diameter 8.0 mm.; height of body whorl, 1 mm. (5a) Section of body whorl, greatly enlarged. Upper part of Paskenta Group; Cottonwood Creek, 3 miles southwest of Ono, Shasta County. p. 128.



CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 28.—CRETACEOUS FOSSILS FROM CALIFORNIA

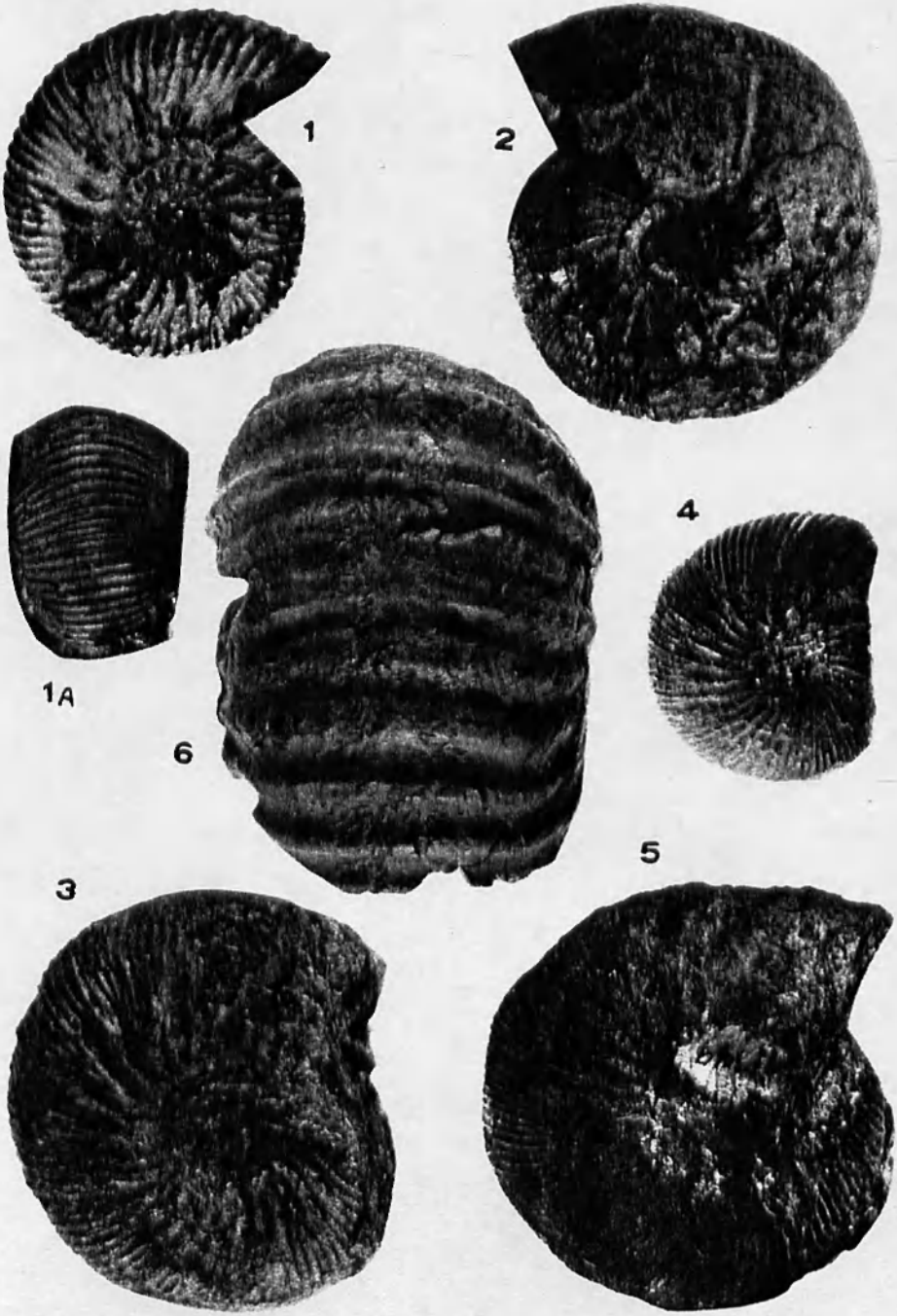
(1, 1a) *Simbirskites broadi* nov. Paratype. Greatest diameter, 45 mm.; thickness of whorl, 20.5 mm. Hamlin—Broad zone, upper part of Paskenta Group; Loc. 113 (C. A. S.), 4 miles southwest of Ono, Shasta County. (1a) Plaster cast from rock mold, showing ventral zone and ribbing on the periphery of the shell. p. 155.

(2) *Dichotomites tehamaensis* nov. Holotype. Greatest diameter, 70 mm.; thickness of whorl, 27 mm. "Zone M_2", Paskenta Group; Loc. 1343 (C. A. S.), Wilcox ranch, 5 miles north of Paskenta, Tehama County. p. 158.

(3, 4) *Dichotomites gregersoni* nov. (3) Holotype, somewhat enlarged. Greatest diameter, 51 mm.; thickness of whorl, 20 mm. "Zone M_2", Paskenta Group; Loc. 1343 (C. A. S.), Wilcox ranch, Tehama County. (4) Paratype, reduced. Greatest diameter, 45 mm. Same locality and horizon as the holotype. p. 158.

(5) *Dichotomites burgeri* nov. Holotype. Greatest diameter, 60 mm.; thickness of whorl, 18 mm. "Zone M_2", Paskenta Group; Loc. 1343 (C. A. S.), Wilcox ranch, 5 miles north of Paskenta, Tehama County. p. 159.

(6) *Cheloniceras flenoyi* nov. Holotype. Length of fragment, 98 mm.; height of whorl, 45 mm.; width of whorl, 67.4 mm. "Zone U", lower part of Horsetown Group; McCarthy Creek, near Paskenta—Lowry road, Tehama County. p. 179.



CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 29.—CRETACEOUS FOSSILS FROM CALIFORNIA

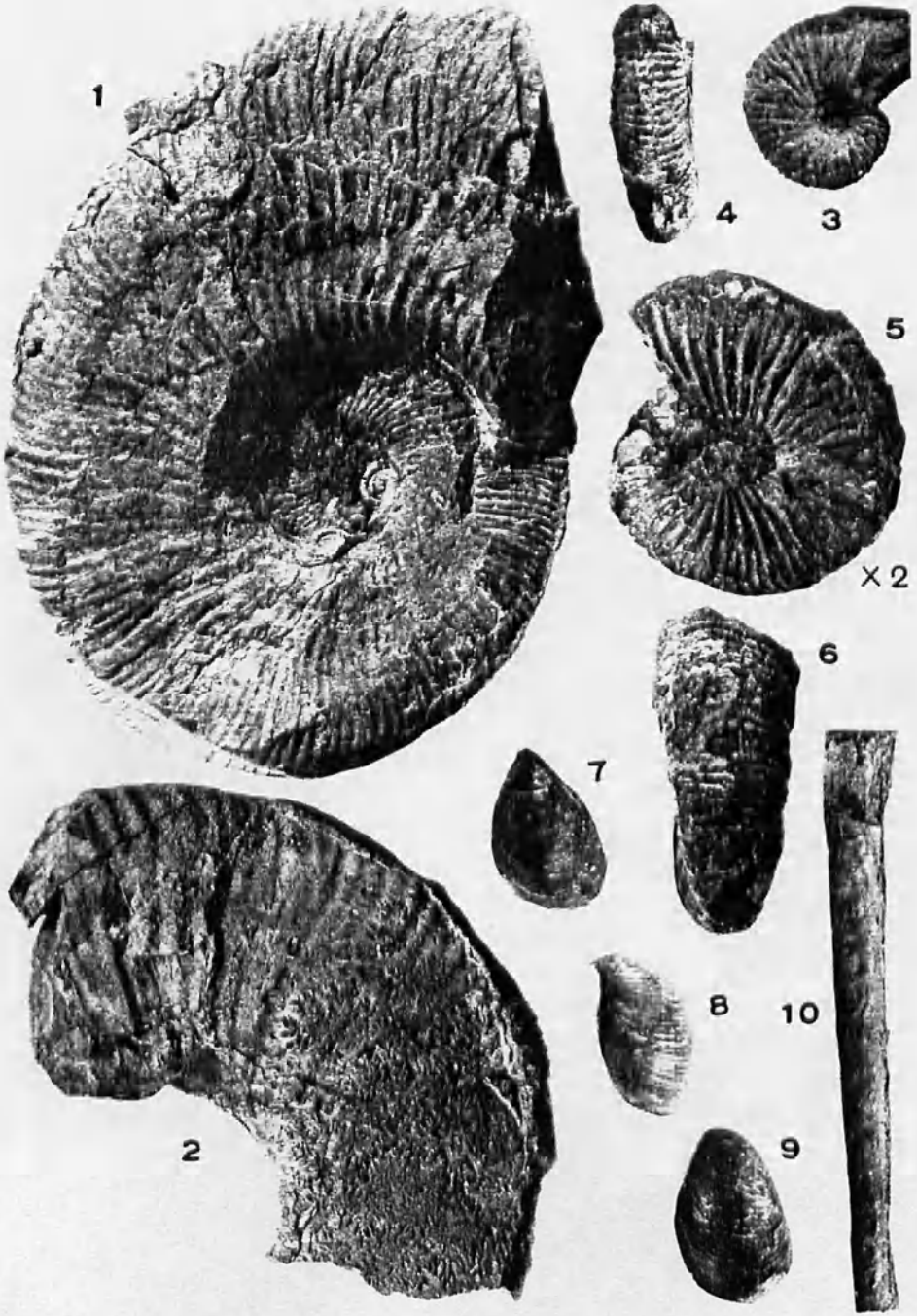
(1) *Neocomites jenkinsi* nov. Holotype. Greatest diameter, 110 mm.; thickness of whorl, 23 mm. "Zone N", Paskenta Group; McCarthy Creek, 3 miles north of Paskenta, Tehama County. p. 165.

(2) *Neocomites stippi* nov. Holotype; cast of one-fourth of the outer whorl, partly septate. Greatest diameter (est.), 105 mm.; thickness of whorl, 21 mm. "Zone M", Paskenta Group; McCarthy Creek, 3 miles north of Paskenta, Tehama County. p. 166.

(3–6) *Thurmannia paskentae* nov. (3, 4) side and top views of holotype, natural size. (5, 6) Side and top views of paratype, enlarged two diameters. "Zone N", Paskenta Group; McCarthy Creek, 3 miles north of Paskenta, Tehama County. p. 162.

(7–9) *Aucella nuciformis* Pavlow. Examples from "Zone N", Paskenta Group; McCarthy Creek, 3 miles north of Paskenta, Tehama County. (7) Right valve. (8, 9) Left valve; back and front views. p. 106.

(10) *Bochianites paskentaensis* nov. Holotype. Length, 67 mm.; greatest diameter, 7 mm. "Zone M_2", Paskenta Group; Wilcox ranch, 5 miles north of Paskenta, Tehama County. p. 167.



CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 30.—CRETACEOUS FOSSILS FROM OREGON

(1–4) *Neocomites riddlensis* nov. (1, 2) Holotype, side and top views. Fragmentary specimen. Greatest diameter (est.), 78 mm.; thickness of whorl, 21 mm. (3) Paratype. Diameter, 61 mm. (4) Small example of same. Diameter, 30 mm. Middle part of Paskenta Group; Loc. 268 (O. S. C.), a mile southeast of Riddle Oregon. p. 167.

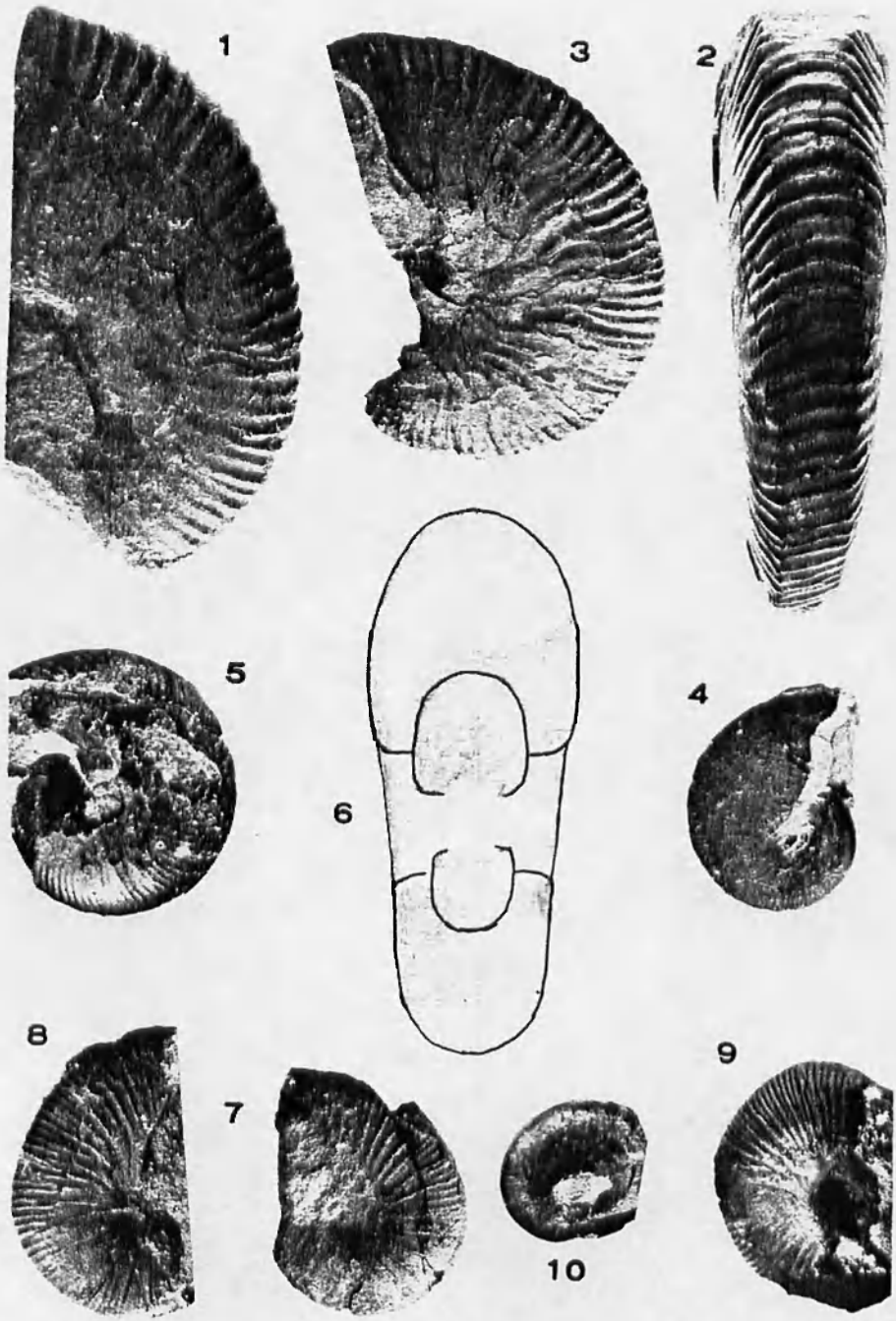
(5) *Dichotomites oregonensis* nov. Holotype. Greatest diameter, 23 mm.; thickness of whorl, 7 mm. Middle part of Paskenta Group; Loc. 268 (O. S. C.), a mile southeast of Riddle, Oregon. p. 159.

(6) *Dichotomites tehamaensis* nov. Section of whorls of holotype. p. 158.

(7) *Phylloceras myrtlense* nov. Diameter, 35 mm.; thickness of whorl, 10 mm. Middle part of Paskenta Group; Loc. 268 (O. S. C.), a mile southeast of Riddle, Oregon. p. 144.

(8) *Phylloceras oregonense* nov. Holotype. Greatest diameter, 40 mm.; thickness of whorl, 16 mm. Middle part of Paskenta Group; Loc. 268 (O. S. C.), a mile southeast of Riddle, Oregon. p. 144.

(9, 10) *Phylloceras umpquanum* nov. (9) Holotype. Greatest diameter, 33 mm.; thickness of whorl, 20 mm. Middle part of Paskenta Group; Loc. 268 (O. S. C.), a mile southeast of Riddle, Oregon. (10) Small example of same species; Loc. 268 (O. S. C.), Riddle, Oregon. p. 143.

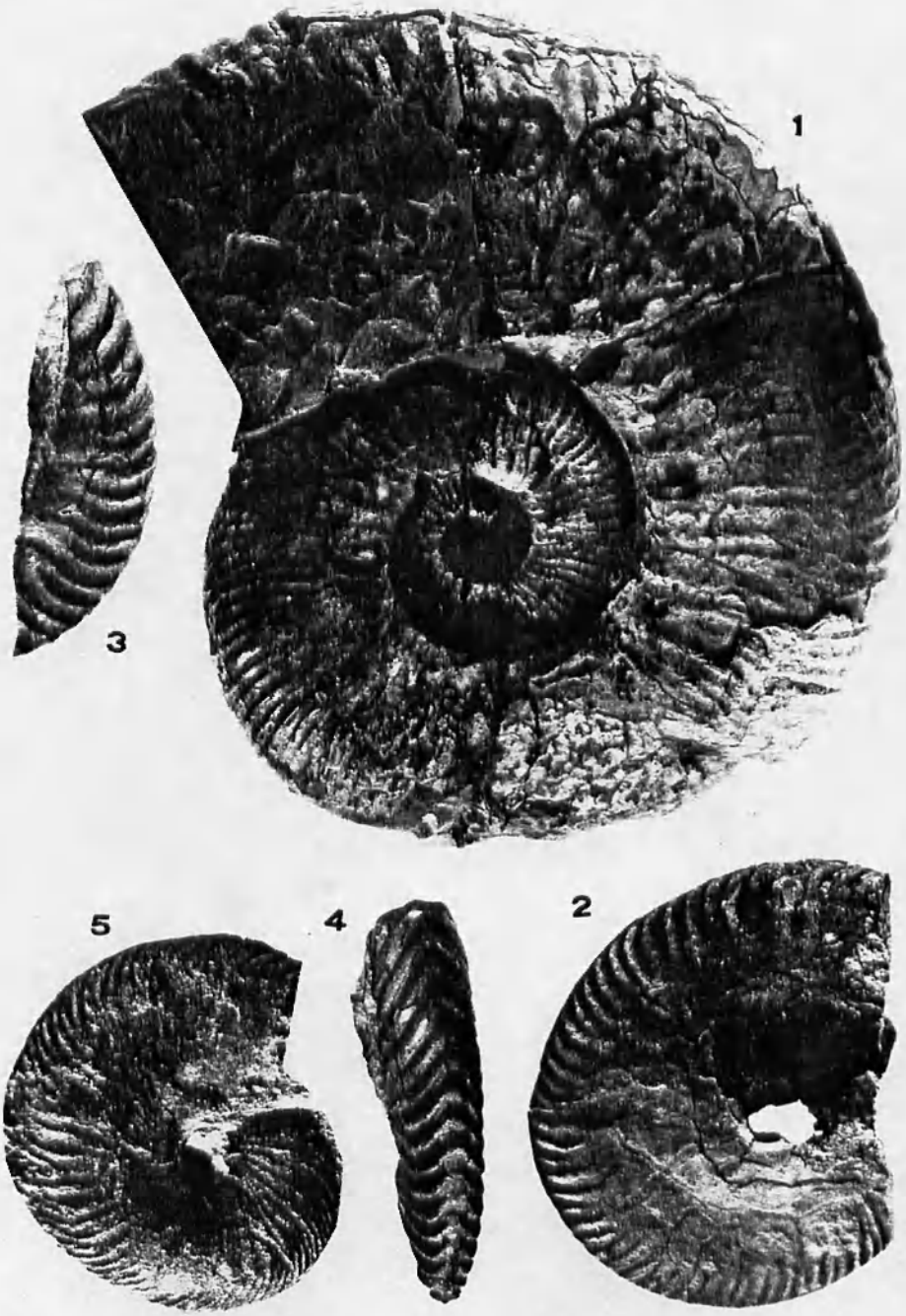


CRETACEOUS FOSSILS FROM OREGON

PLATE 31.—CRETACEOUS FOSSILS FROM CALIFORNIA AND OREGON

(1) *Thurmannia jupiter* nov. Holotype. Greatest diameter, 230 mm.; thickness of whorl, 65 mm. Hamlin—Broad zone, upper part of Paskenta Group; 3 miles southwest of Ono, Shasta County. p. 162.

(2-5) *Lyticoceras packardi* nov. (2) Holotype. Greatest diameter, 66 mm.; thickness of whorl, 15 mm. (3) Side view of paratype. (4) Peripheral view of same fragment. Middle part of Paskenta Group; Loc. 268 (O. S. C.), a mile southeast of Riddle, Oregon. p. 164. (5) Plesiotype, enlarged; greatest diameter, 31 mm.; width of umbilicus, 5 mm.; Loc. 268 (O. S. C.), as above.



CRETACEOUS FOSSILS FROM CALIFORNIA AND OREGON

PLATE 32.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1) *Parahoplitoides seniloides* nov. Holotype. Greatest diameter, 241 mm.; thickness of whorl, 60 mm. Shoup zone, middle part of Horsetown Group; south of the Shoup ranch, 4.5 miles south of Ono, Shasta County. p. 168.

(2) *Parahoplitoides shoupi* nov. Holotype. Greatest diameter, 202 mm.; thickness of whorl, 50 mm. Shoup zone, immediately above the Argonaut zone, on the Shoup ranch on Bee Creek, 4 miles south of Ono, Shasta County. p. 168.

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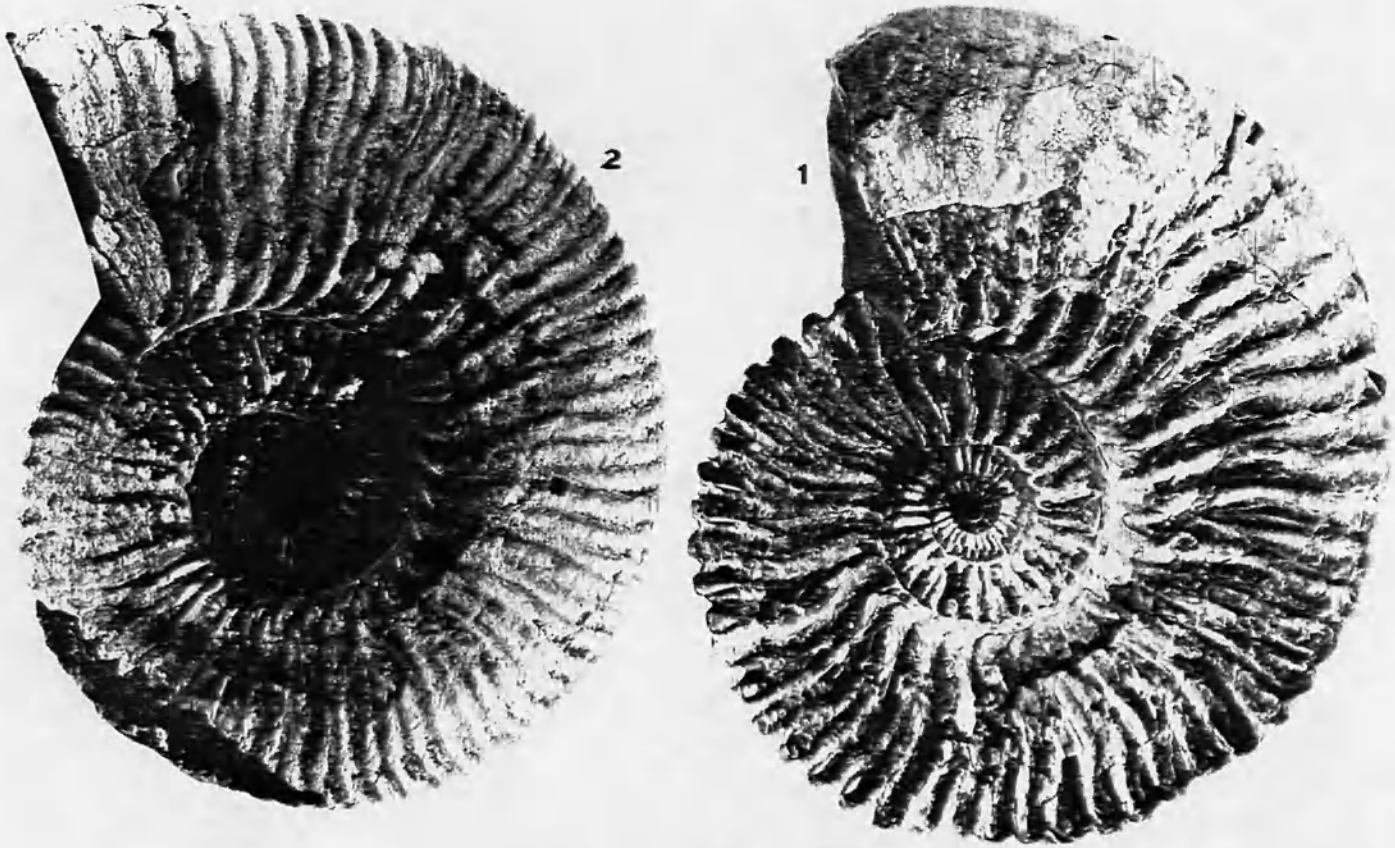
CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 33.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1) *Parahoplitoides cerrosensis* nov. Holotype. Greatest diameter, 135 mm.; thickness of whorl, 58 mm. Shoup zone, a little above the Argonaut zone of the Horsetown Group; Loc. 1347 (C. A. S.) east of Mitchell Creek, 6 miles south of Ono, Shasta County. p. 168.

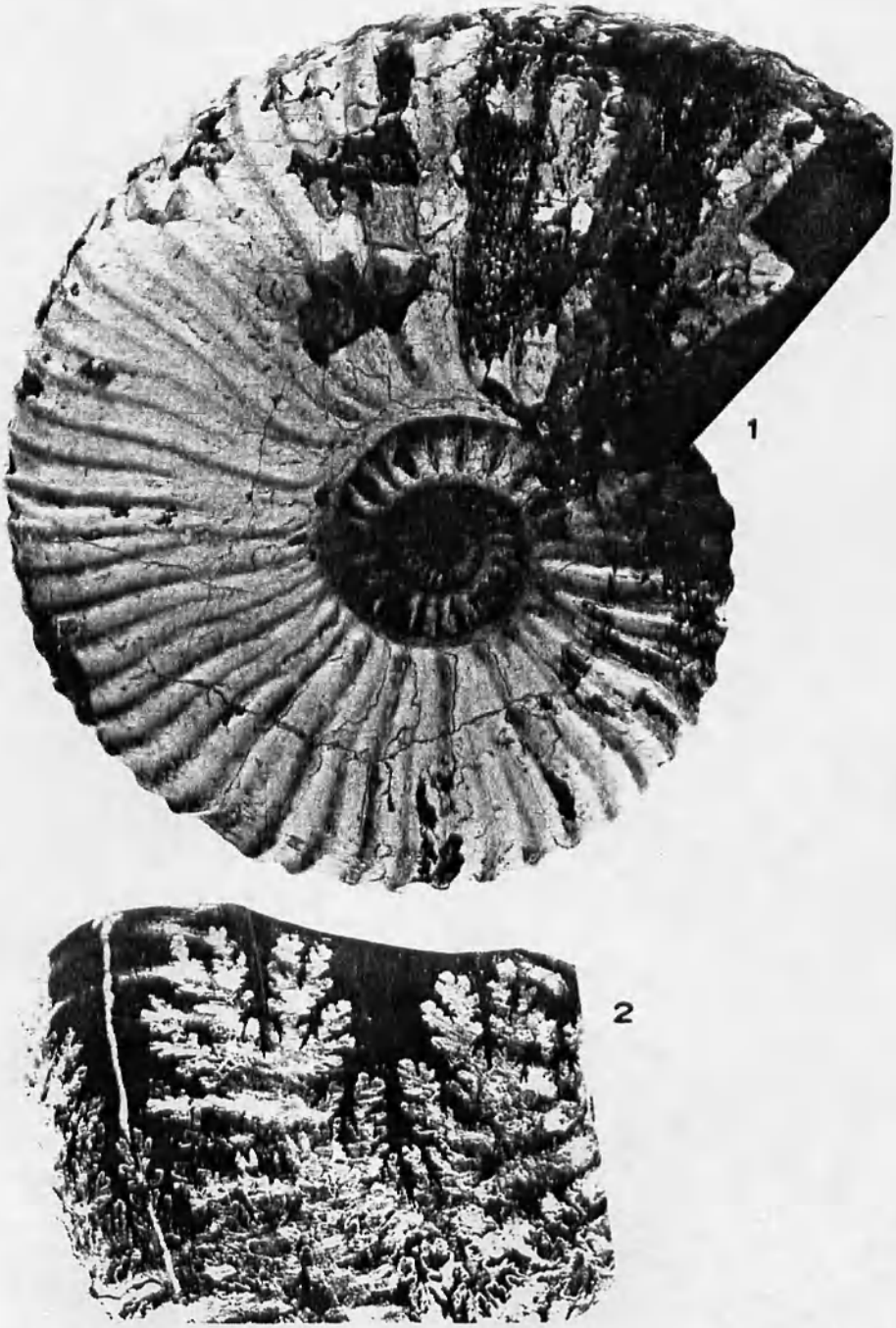
(2) *Parahoplites stantoni* nov. Holotype. Greatest diameter, 146 mm.; thickness of whorl, 45 mm. Upper middle Horsetown Group; Loc. 1348 (C. A. S.), Alderson Creek, 2 miles south of Ono, Shasta County. p. 169.



CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 34.—CRETACEOUS FOSSIL FROM CALIFORNIA

Parahoplites dallasi nov. (1) Holotype. Greatest diameter, 135 mm.; thickness of whorl, 58 mm. Shoup zone, upper middle Horsetown Group; Loc. 1347 (C. A. S.), east of Mitchell Creek, 5.5 miles south of Ono, Shasta County. (2) Fragment of an example showing suture line. Horizon and locality, as given above. p. 169.



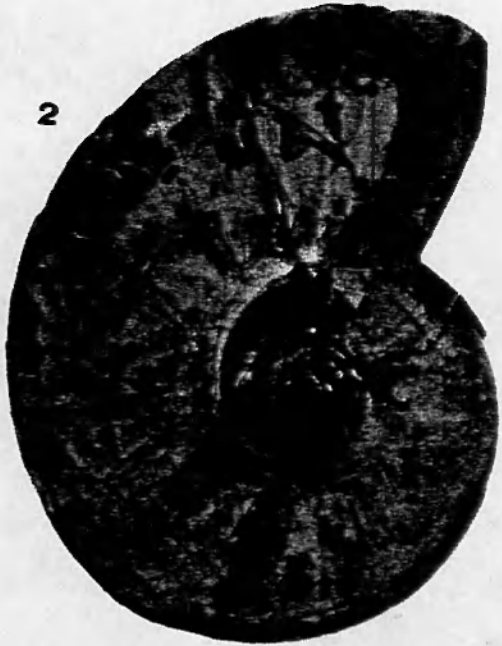
CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 35.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1) *Parahoplites macfarlandi* nov. Holotype. Greatest diameter, 209.5 mm.; thickness of whorl, 75 mm. Probably from the Shoup zone, upper middle Horsetown Group; Loc. 1348 (C. A. S.), Alderson Creek, 2 miles south of Ono, Shasta County. p. 170.

(2) *Lytoceras* (*Gabbioceras*) *angulatum* Anderson. Plesiotype. Near natural size. Middle Horsetown Group; Loc. 1347 (C. A. S.), east of Mitchell Creek, 6 miles south of Ono, Shasta County. p. 150.

1



2

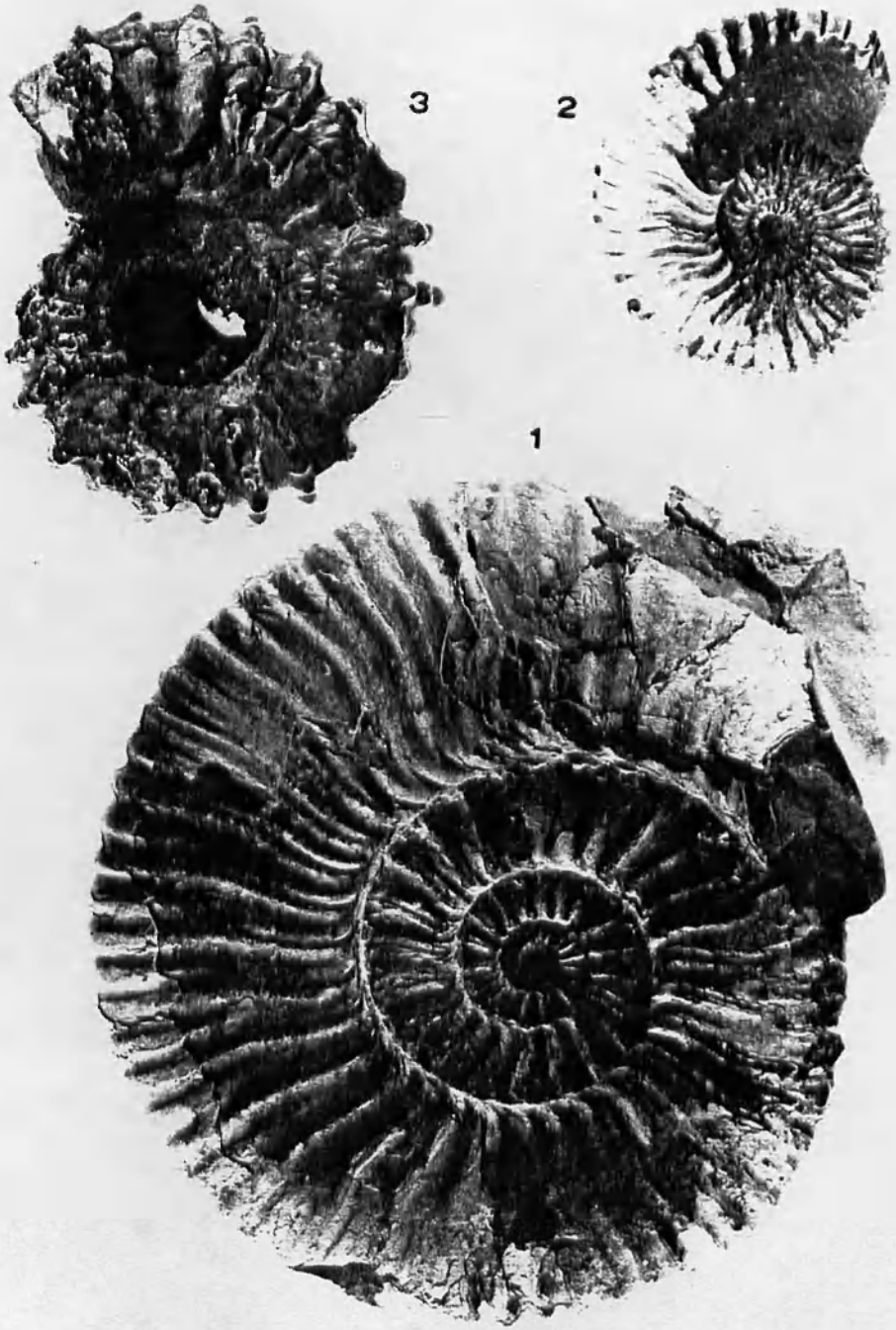
CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 36.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1) *Acanthoplites aegis* nov. Holotype. Greatest diameter, 235 mm.; thickness of whorl, 56 mm. Upper middle Horsetown Group; Loc. 1348 (C. A. S.), Alderson Creek, 2 miles south of Ono, Shasta County. p. 171.

(2) *Parahoplites stantoni* nov. Paratype. Young example from the Barr zone, middle Horsetown Group; Loc. 1347 (C. A. S.), Mitchell Creek, 6 miles south of Ono, Shasta County. p. 169.

(3) *Douvilleiceras aff. mammillatum* (Schlotheim), var. An example from the upper part of the Horsetown Group; Loc. 1668 (C. A. S.), east branch of Hulen Creek, Shasta County. Greatest diameter, 83 mm.; thickness of whorl, 45 mm. p. 174.

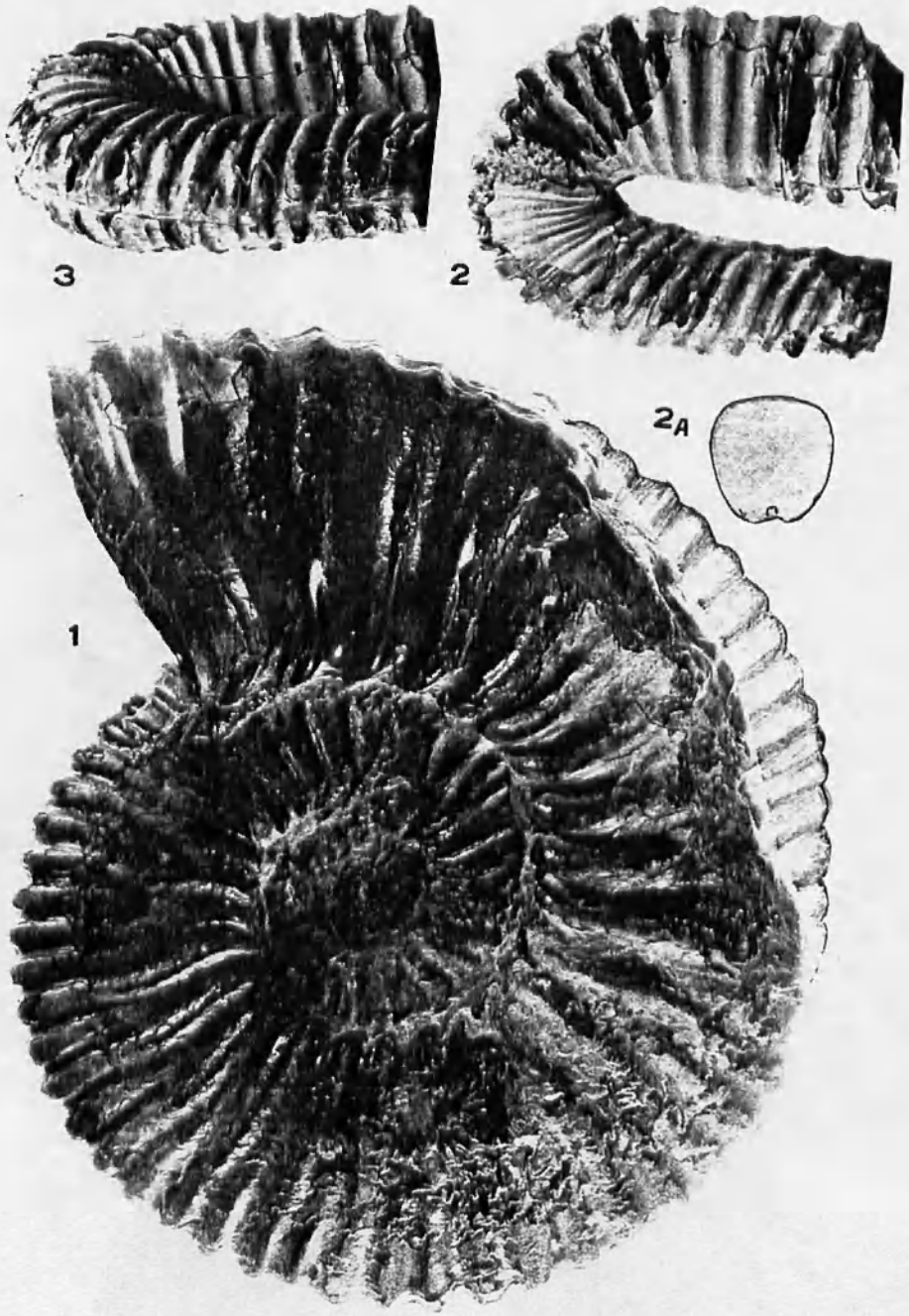


CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 37.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1) *Acanthoplites gardneri* nov. Holotype. Greatest diameter, 220 mm.; thickness of whorl, 69 mm. Probably near the Shoup zone, upper middle Horsetown Group; North fork of Cottonwood Creek, east of Ono, Shasta County. p. 172.

(2, 2a, 3) *Hamiliceras aequicostatum* (Gabb). Topotype, showing the more complete form of the species. (2) Side view, showing the manner of ribbing, and change in obliquity. (2a) Section of smaller limb. (3) Oblique view of both limbs, showing the siphonal zone, and the weak tubercules bordering it. p. 216.



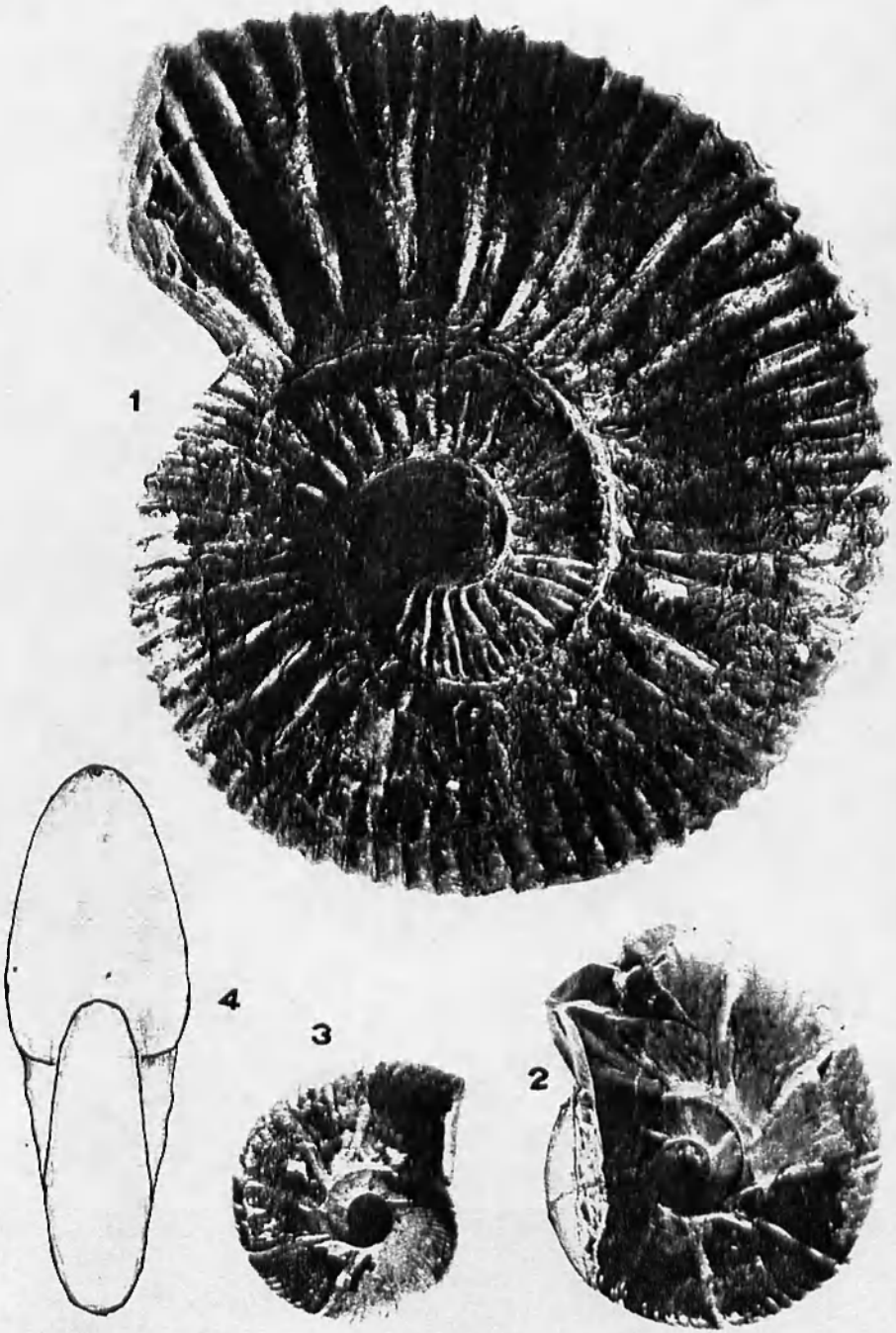
CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 38.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1) *Acanthoplites perrini* nov. Holotype. Greatest diameter, 230 mm.; thickness of whorl, 65 mm. Perrin zone, upper part of Horsetown Group; Loc. 1668 (C. A. S.), east branch of Hulen Creek, Shasta County. p. 173.

(2, 3) *Puzosia reesidei* nov. (2) Holotype, a little enlarged. Greatest diameter, 49 mm.; thickness of whorl, 14 mm. (3) Paratype. Diameter, 38 mm. Buenaventura zone, upper part of Horsetown Group; Loc. 1346-A, west branch of Hulen Creek, Shasta County. p. 187.

(4) Section of *Cleoniceras lecontei* (Anderson). Greatest diameter of holotype, 85 mm. p. 192.



CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 39.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1) *Acanthoplites remondi* (Gabb). Holotype. Greatest diameter, 137 mm.; thickness of whorl, 37 mm. Upper part of Horsetown Group; Locality of discovery not definitely known, but probably from near the Buenaventura zone on the North fork of Cottonwood Creek, Shasta County. p. 172.

(2) *Puzosia aldersona* nov. Holotype. Greatest diameter, 180 mm.; thickness of whorl, 65 mm. Near Perrin zone, upper part of Horsetown Group; Alderson Creek, 2 miles south of Ono, Shasta County. p. 186.

CRETACEOUS FOSSILS FROM CALIFORNIA

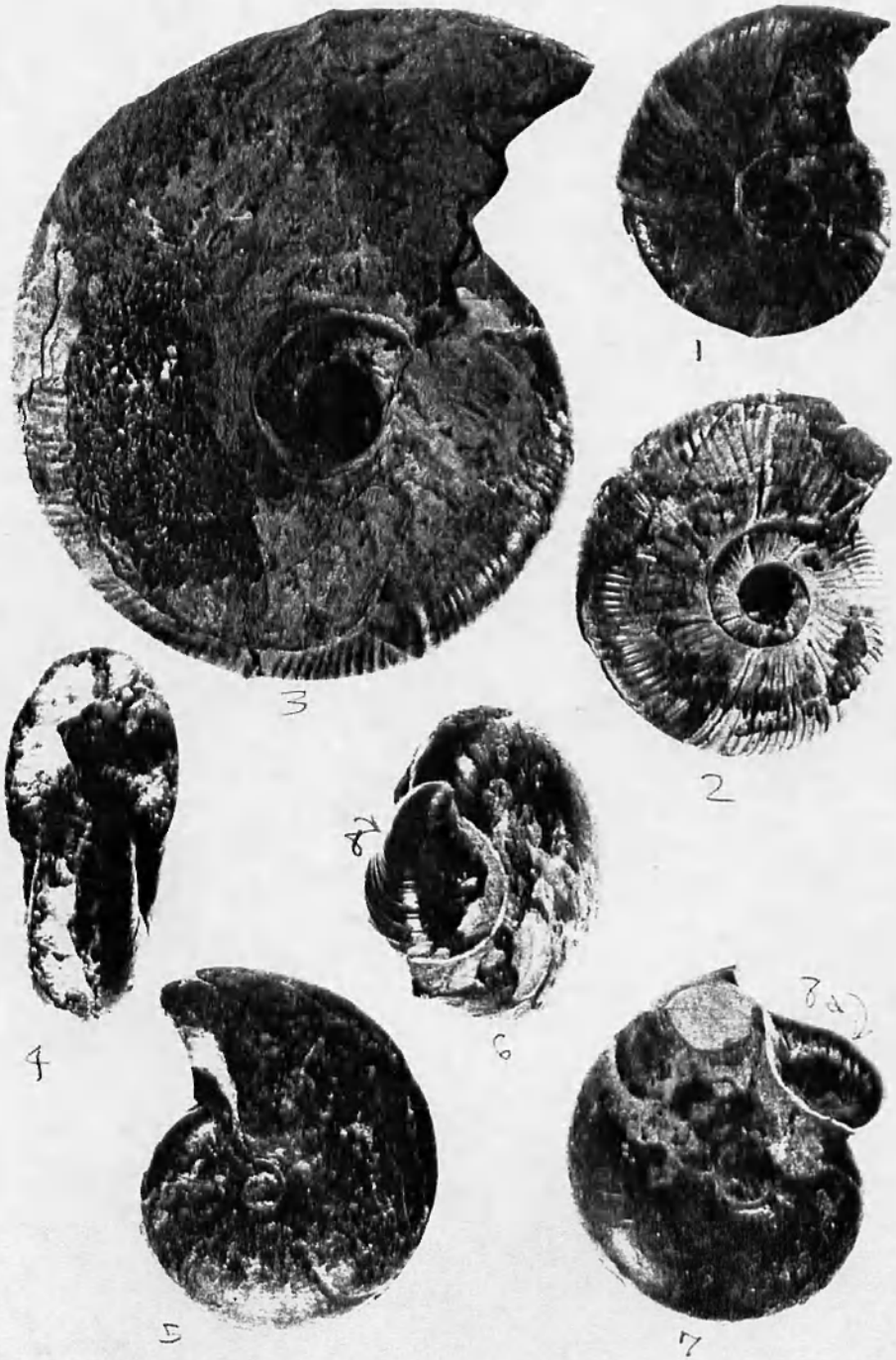
PLATE 40.—CRETACEOUS FOSSILS FROM CALIFORNIA AND BRITISH COLUMBIA

(1, 2) *Melchiorites shastensis* nov. (1) Holotype. Greatest diameter, 106 mm.; thickness of whorl, 39 mm. (2) Paratype, young example; diameter, 46 mm. Near the Argonaut zone, upper middle Horsetown Group; Loc. 1348 (C. A. S.), Alderson Creek, 2 miles south of Ono, Shasta County. p. 182.

(3) *Puzosia buenaventura* nov. Young example, showing character of costation and constrictions in youth. p. 185.

(4–7) *Desmoceras voyi* Anderson. (4, 5) Holotype, side and front views. Greatest diameter, 53.3 mm.; thickness of whorl, 28 mm. Near Argonaut zone, middle part of Horsetown Group; Cottonwood Creek, east of Ono, Shasta County. (6, 7) Example from Lower Cretaceous beds on Graham Island, British Columbia, with *Aucella indigenalis* adhering. Side and oblique views, natural size. p. 180.

(8, 8a) *Aucella indigenalis* nov. Plesiotype; showing back and side views of right valve, adhering to *Desmoceras voyi* Anderson. Loc., 2 miles north of Skidegate Indian village, Graham Island, B. C. p. 107.

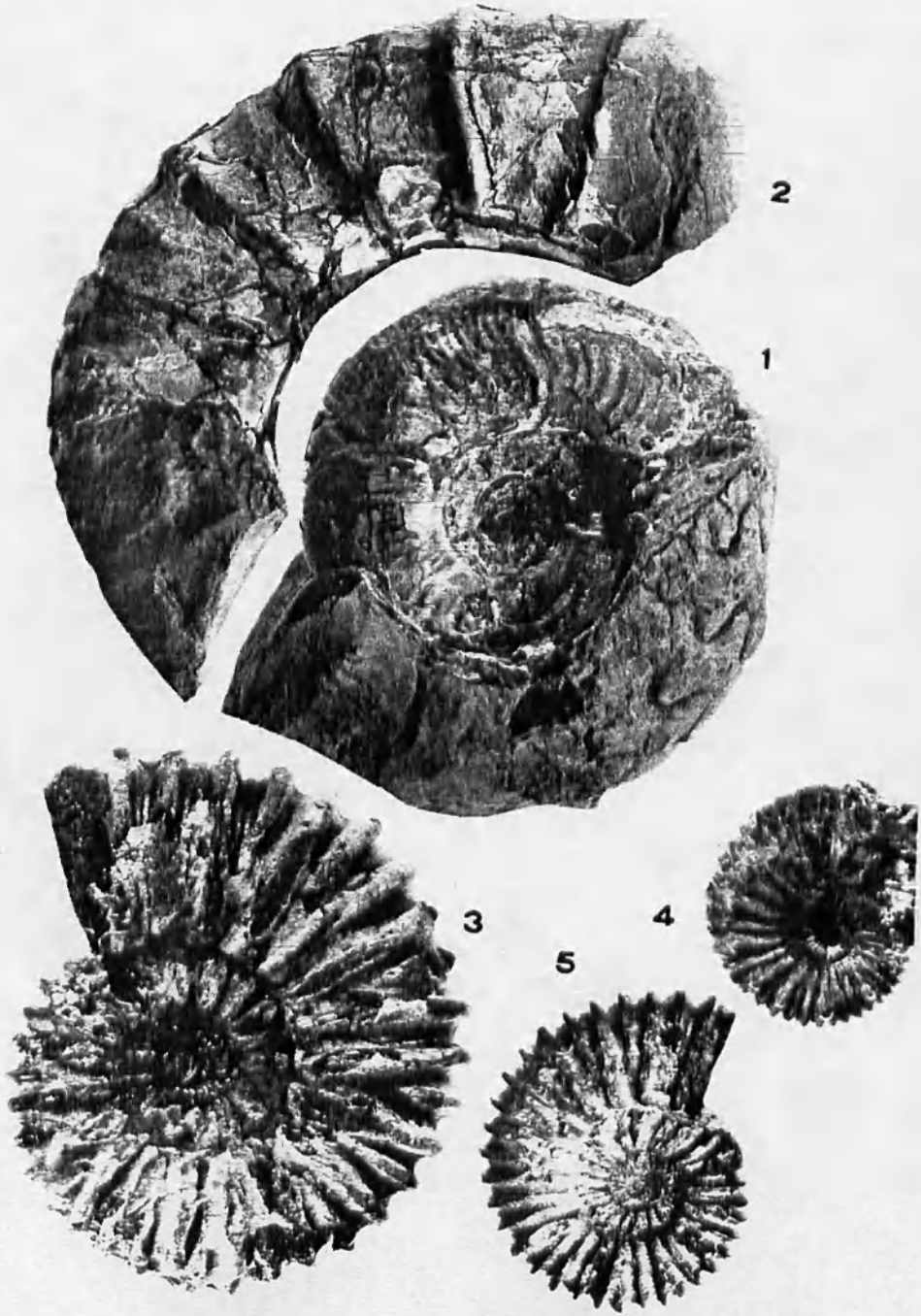


CRETACEOUS FOSSILS FROM CALIFORNIA AND BRITISH COLUMBIA

PLATE 41.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1, 2) *Pseudocia buenaventura* nov. Holotype. (1) Inner coil, showing character of ribbing at maturity. (2) Body chamber, detached, showing ribbing in senal stage of growth. Greatest diameter, including body-chamber, 160 mm.; diameter exclusive of detached portion, 105 mm.; thickness of whorl, 41 mm. Buenaventura zone, upper part of Horsetown Group; near Loc. 1346-A (C. A. S.), west branch of Hulen Creek, Shasta County. p. 185.

(3–5) *Acanthoplites spathi* nov. (3) Holotype. Greatest diameter, 70 mm.; thickness of whorl, 26 mm. (4) Paratype. Greatest diameter, 32 mm.; thickness of whorl, 15 mm., showing spine-like processes of the younger whorls near whorl suture. (5) An example of intermediate size. Buenaventura zone, upper part of Horsetown Group; Loc. 1346-A (C. A. S.), west branch of Hulen Creek, Shasta County. p. 173.



CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 42.—CRETACEOUS FOSSILS FROM CALIFORNIA

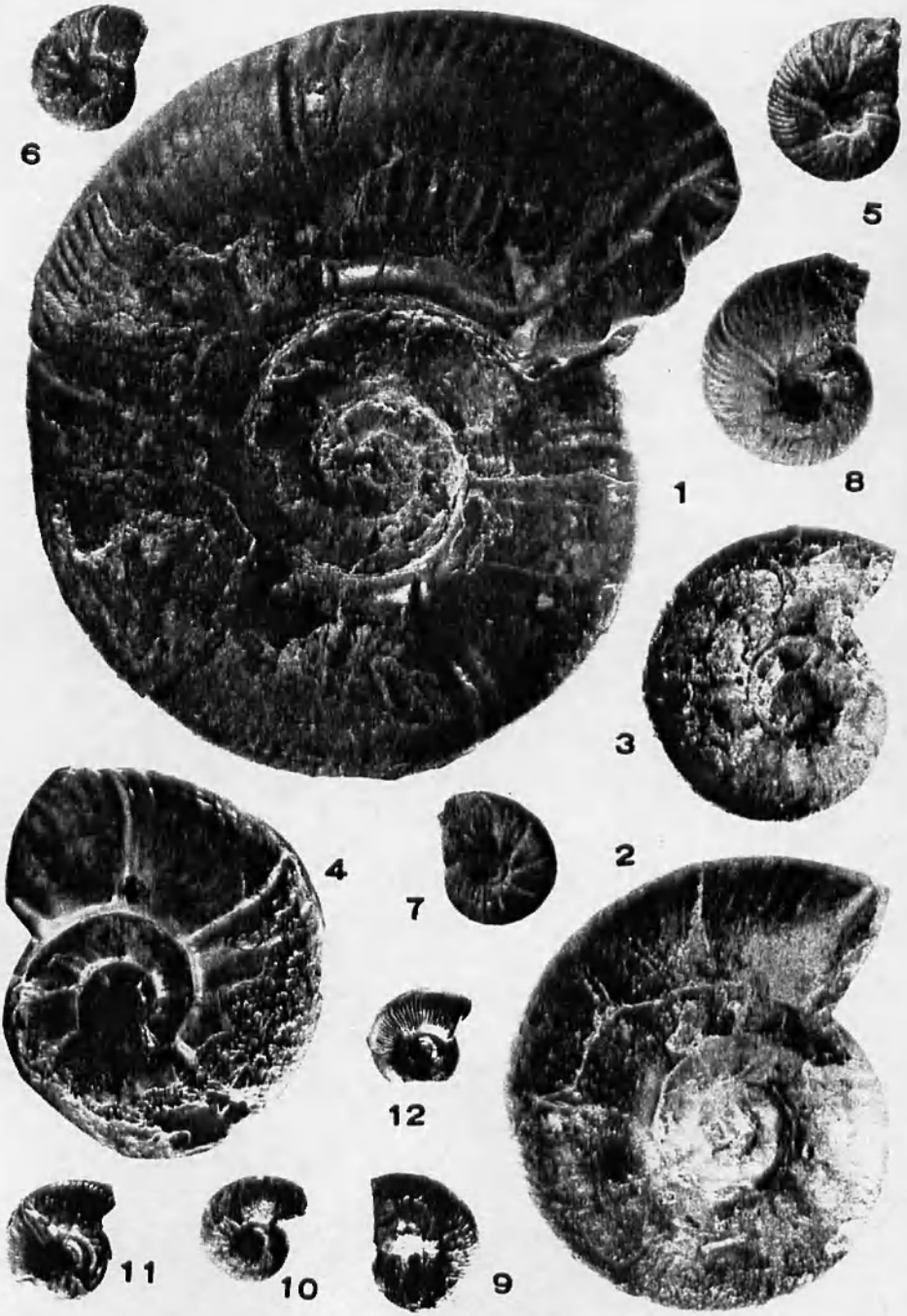
(1–3) *Puzosia dilleri* (Anderson). (1) Holotype. Greatest diameter, 115 mm.; thickness of whorl, 46 mm. (2, 3) Plesiotypes. Occurs above the Buenaventura zone, upper part of Horsetown Group; east branch of Hulen Creek, Shasta County. p. 185.

(4) *Puzosia weaveri* nov. Holotype. Greatest diameter, 55 mm.; thickness of whorl, 20 mm. Three miles east of Rodeo, Contra Costa County. p. 189.

(5–7) *Puzosia jimboi* nov. (5) Holotype. Greatest diameter, 23 mm.; thickness of whorl, 9 mm. (6) Paratype. Greatest diameter, 19 mm. (7) Plesiotype. From the uppermost beds of the Horsetown Group, a mile east of Horsetown. p. 188.

(8) *Puzosia anona* nov. Holotype. Greatest diameter, 30 mm.; thickness of whorl, 10 mm. A mile east of Horsetown, Shasta County. p. 188.

(9–12) *Puzosia diadema* nov. (9) Holotype. Greatest diameter, 20 mm.; thickness of whorl, 6 mm. (10) Paratype. Diameter, 16 mm. (11, 12) Plesiotypes. Found in Buenaventura zone, upper part of Horsetown Group; Loc. 1346-A (C. A. S.), west branch of Hulen Creek, Shasta County. p. 188.



CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 43.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1, 2) *Desmoceras merriami* Anderson. Topotypes, a little enlarged. (1) Septate throughout, showing form and surface features. (2) Showing ventral area, thickness and septation. Found in Neptune zone, upper part of Horsetown Group; Loc. 1659 (C. A. S.), east branch of Hulen Creek, Shasta County. p. 181.

(3) *Beudanticeras breweri* (Gabb). Example from the Cottonwood Creek, Collections of Stanford University. Septate throughout, much reduced in size. Courtesy of S. W. Muller. p. 189.

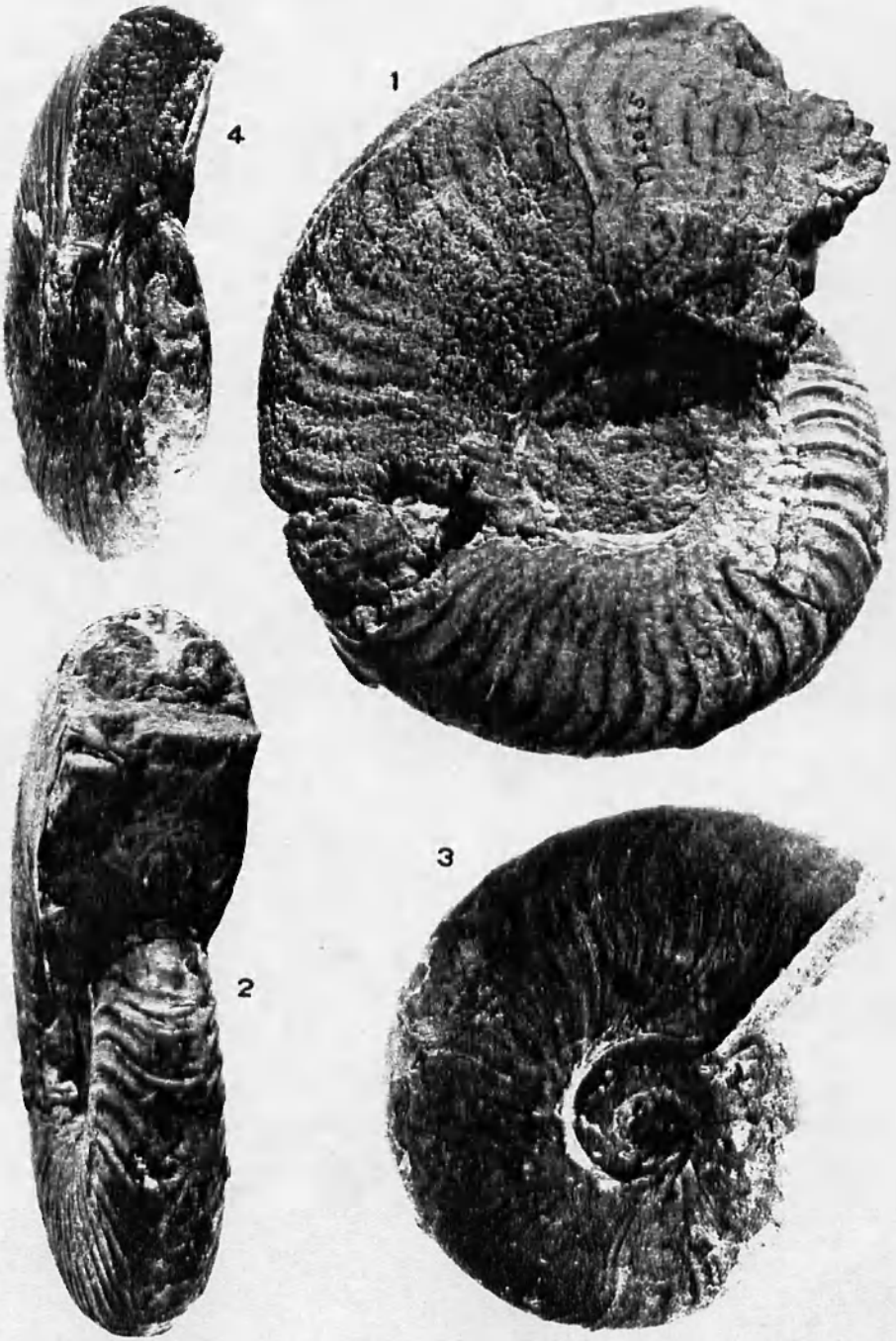
(4, 5) *Hamites imitator* nov. Holotype, and reflected end view. Reduced in size. Length 67 mm.; dorso-ventral diameter, 43 mm. Found in Perrin zone, Loc. 1668 (C. A. S.), east branch of Hulen Creek, Shasta County. p. 218.

CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 44.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1, 2) *Beudanticeras breweri* (Gabb). Holotype, side and front views. Greatest diameter, wholly septate, 122 mm.; thickness of whorl, 32 mm. Property of the Academy of Natural Sciences, Philadelphia. Courtesy of H. A. Pilsbry. p. 189.

(3, 4) *Beudanticeras hulenense* nov. Holotype. Much reduced in size. Greatest diameter, partly non-septate, 128 mm.; thickness of whorl, 32 mm. Found in Neptune zone, upper part of Horsetown Group, Loc. 1659 (C. A. S.), east branch of Hulen Creek. p. 190.

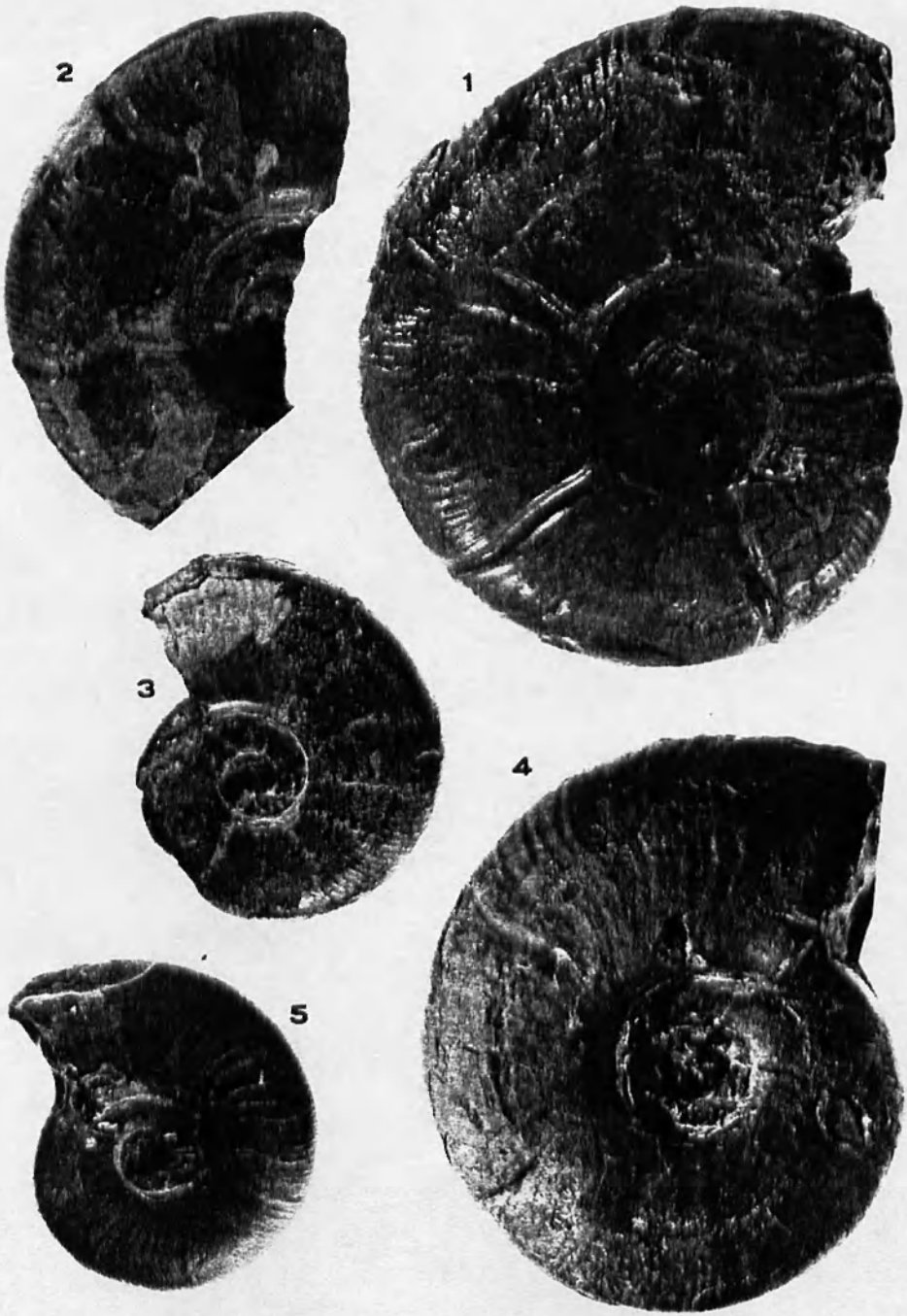


CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 45.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1, 2) *Puzosia hoffmanni* (Gabb). Topotypes. (1) Lectotype. Greatest diameter, 86 mm.; thickness of whorl, 30 mm. Upper beds of the Horsetown Group; Loc. 1344 (C. A. S.), old Horsetown, Shasta County. (2) Plesiotype, from the same locality and horizon. p. 186.

(3–5) *Puzosia subquadrata* (Anderson). (3) Holotype, size reduced. Greatest diameter, 72 mm.; thickness of whorl, 29 mm. Neptune zone, upper part of Horsetown Group; Loc. 1659 (C. A. S.), east branch of Hulen Creek, Shasta County. (4) Plesiotype. Greatest diameter, 102 mm.; thickness of whorl, 40 mm. (5) A smaller example of the same, from the same locality. All specimens from Loc. 1659 (C. A. S.). p. 186.



CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 46.—CRETACEOUS FOSSILS

(1) *Puzosia dilleri* (Anderson). Holotype, front view. (*See* Pl. 42). p. 185.

(2-4) *Cheloniceras irregulare* nov. Holotype. (2) Side view of inner (mostly septate) whorl. Greatest diameter, 110 mm.; thickness of whorl, 33 mm. (3) Detached portion of body-chamber, size reduced, showing loss of ventro-lateral tubercules. (4) Plaster cast made from mold on the dorsal side of body-chamber (Fig. 3) showing tubercules. p. 178.

CRETACEOUS FOSSILS

PLATE 47.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1) *Cheloniceras reesidei* nov. Holotype. Greatest diameter, 90 mm.; thickness of whorl (est.), 30 mm. Found a little below the Buenaventura zone, upper part of Horsetown Group; near Loc. 1346-A, west branch of Hulen Creek, Shasta County. p. 178.

(2) *Cheloniceras stoliczkanum* (Gabb). Holotype. Academy of Natural Sciences, Philadelphia. Greatest diameter, 90 mm.; thickness of whorl, 46 mm. Probably from the Bradley zone, upper part of Horsetown Group; Hulen Creek, Shasta County. p. 176.

(3–5) *Cleoniceras lecontei* (Anderson). (3) Holotype. Greatest diameter, 72 mm.; thickness of whorl, 26 mm. Perrin zone, upper part of Horsetown Group; Loc. 152 (C. A. S.), east branch of Hulen Creek, Shasta County. (4, 5) Plesiotypes. Perrin zone, Loc. 1668 (C. A. S.), east branch of Hulen Creek, Shasta County. p. 192.

CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 48.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1, 1a) *Acanthoplites barryana* nov. Holotype. (1) Inner coil, almost wholly septate. (1a) Detached portion of body-chamber. Greatest diameter of coiled portion, 110 mm.; thickness of whorl, 30 mm. Probably from horizon above the Perrin zone, Hulen Creek, Shasta County. p. 174.

(2, 3) *Beudanticeras haydeni* (Gabb). Plesiotype. Greatest diameter, 57 mm.; thickness of whorl, 14 mm. Near top of Horsetown Group; Loc. 1344 (C. A. S.), old Horsetown, Shasta County. p. 190.

(4–7) *Sonneratia crossi* nov. (4) Holotype. Greatest diameter, 50 mm.; thickness of whorl, 17 mm. Near top of Horsetown Group; Loc. 1344 (C. A. S.), old Horsetown, Shasta County. (5–7). Smaller examples of same, from type locality. p. 196.

CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 49.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1–3) *Sonneratia sacramentica* (Anderson). (1, 2) Holotype, a little enlarged. Side and front views. Greatest diameter, 102 mm.; thickness of whorl, 36 mm. Probably from the Perrin zone, upper part of Horsetown Group; Loc. 152 (C. A. S.), east branch of Hulen Creek. (3) Young example of same species from the same locality. p. 195.

(4, 5) *Sonneratia taffi* nov. (4) Holotype. Greatest diameter, 71 mm.; thickness of whorl, 25 mm. (5) Paratype. Greatest diameter, 43 mm. Perrin zone, upper Horsetown Group; Loc. 152 (C. A. S.), east branch of Hulen Creek, Shasta County. p. 194.

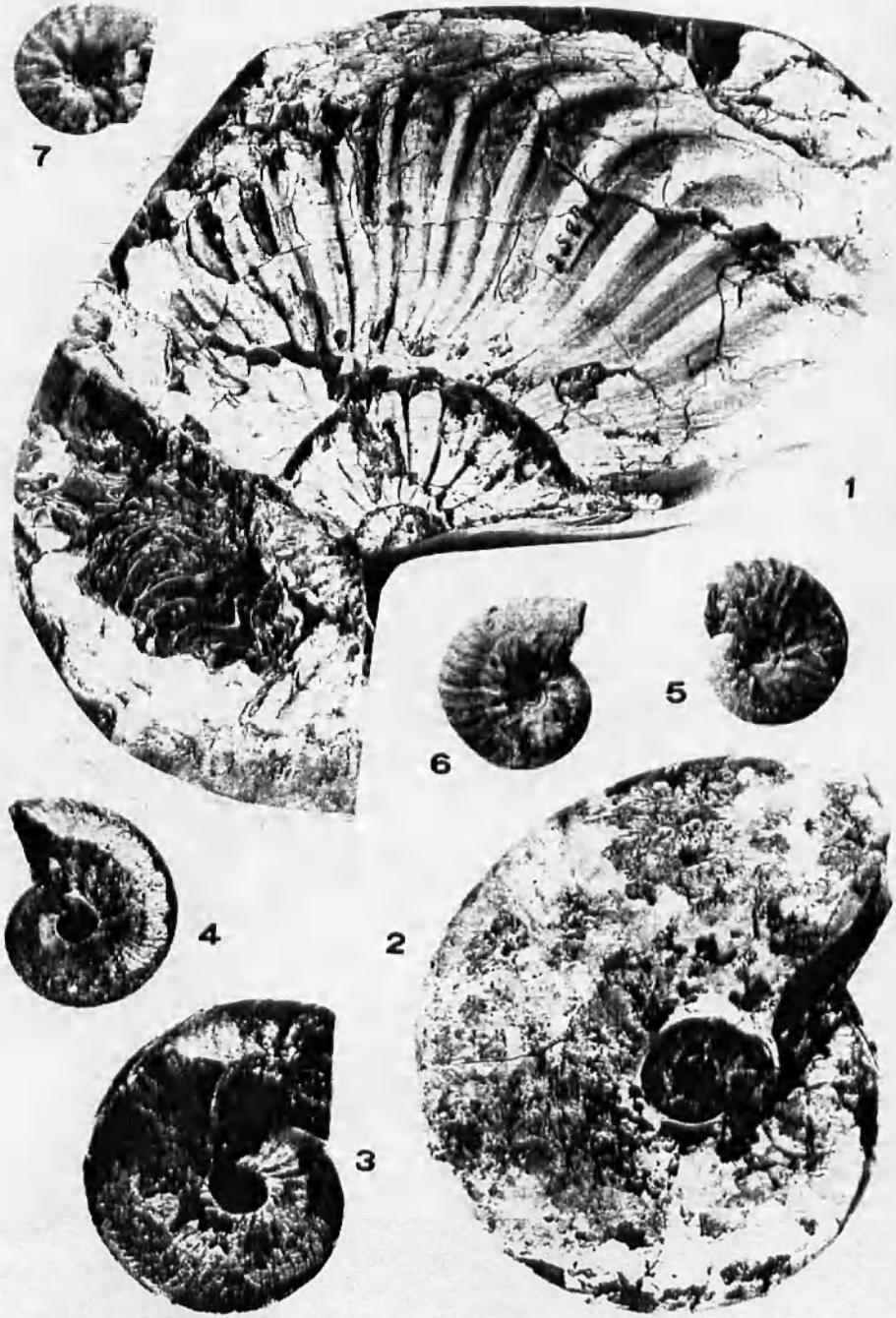
CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 50.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1) *Oxytropidoceras packardi* nov. Holotype, size a little reduced. Greatest diameter (est.), 176 mm.; thickness of whorl, 45 mm. Near Neptune zone, upper part of Horsetown Group; Alderson Creek, 2 miles south of Ono, Shasta County. p. 198.

(2–4) *Cleoniceras modestum* nov. (2) Holotype. Greatest diameter, 80 mm.; thickness of whorl, 24 mm. (3) Paratype. Greatest diameter, 43 mm.; thickness of whorl, 13 mm. (4) Young example of the same, diameter, 30 mm. A little above the Perrin zone, upper part of the Horsetown Group; near Loc. 1668 (C. A. S.), east branch of Hulen Creek, Shasta County. p. 193.

(5–7) *Sonneratia stantoni* Anderson. Plesiotypes. Upper beds of the Horsetown Group; Loc. 1344 (C. A. S.), old Horsetown, Shasta County. p. 196.



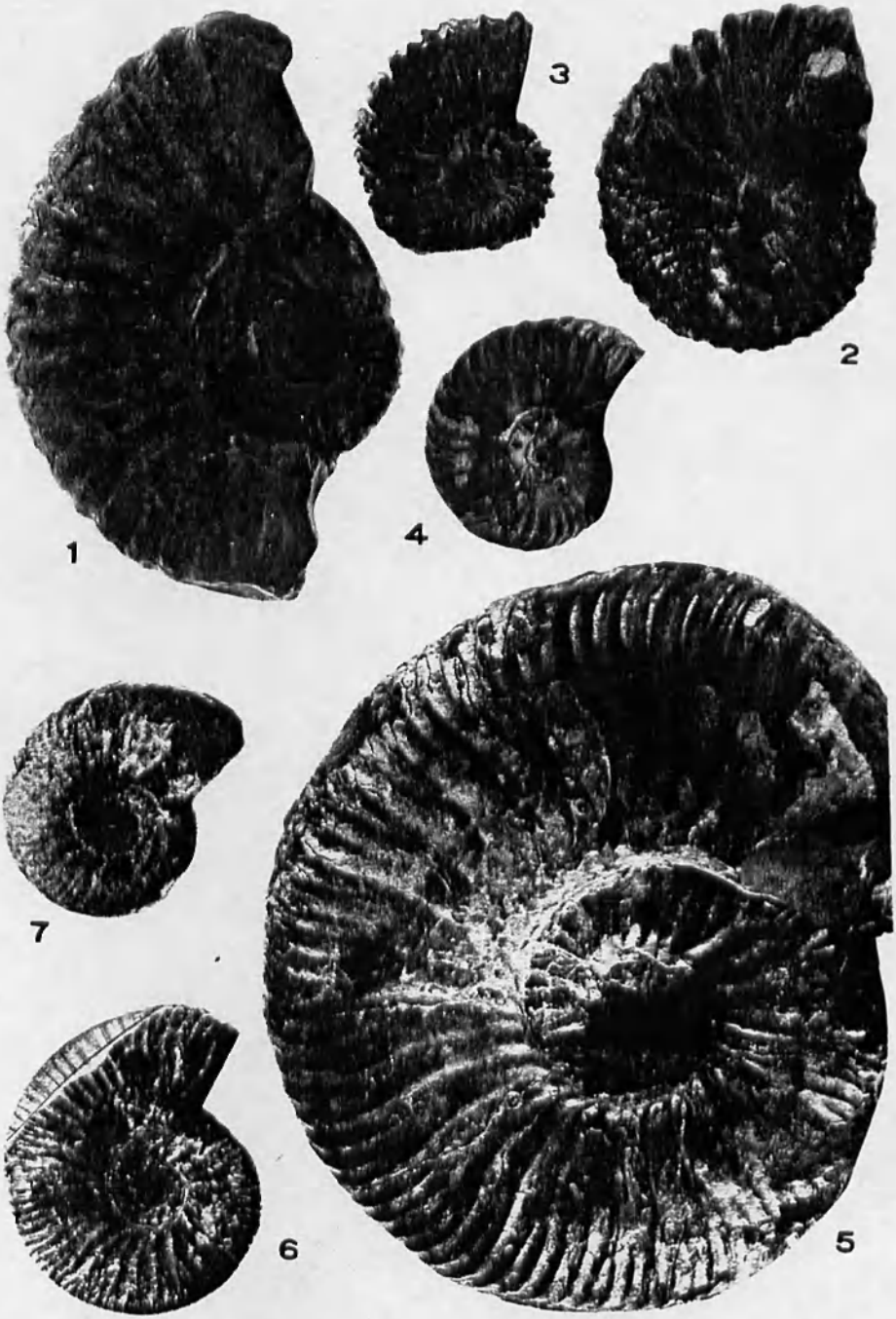
CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 51.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1–3) *Cheloniceras* (*Prochelonicerας*) *hindsi* nov. (1) Holotype. Greatest diameter, 80 mm.; thickness of whorl, 40 mm. (2, 3) Smaller examples of the same species, showing changes in ribbing and in ornamentation with growth. Probably near the Barr zone, lower Horsetown Group; Fiddler Creek, near Middle fork of Cottonwood Creek, Shasta County. p. 179.

(4) *Sonneratia mulleri* nov. Paratype. Greatest diameter, 33 mm.; thickness of whorl, 12 mm. About 300 feet beneath the Perrin zone, upper part of the Horsetown Group; east branch of Hulen Creek, Shasta County. p. 195.

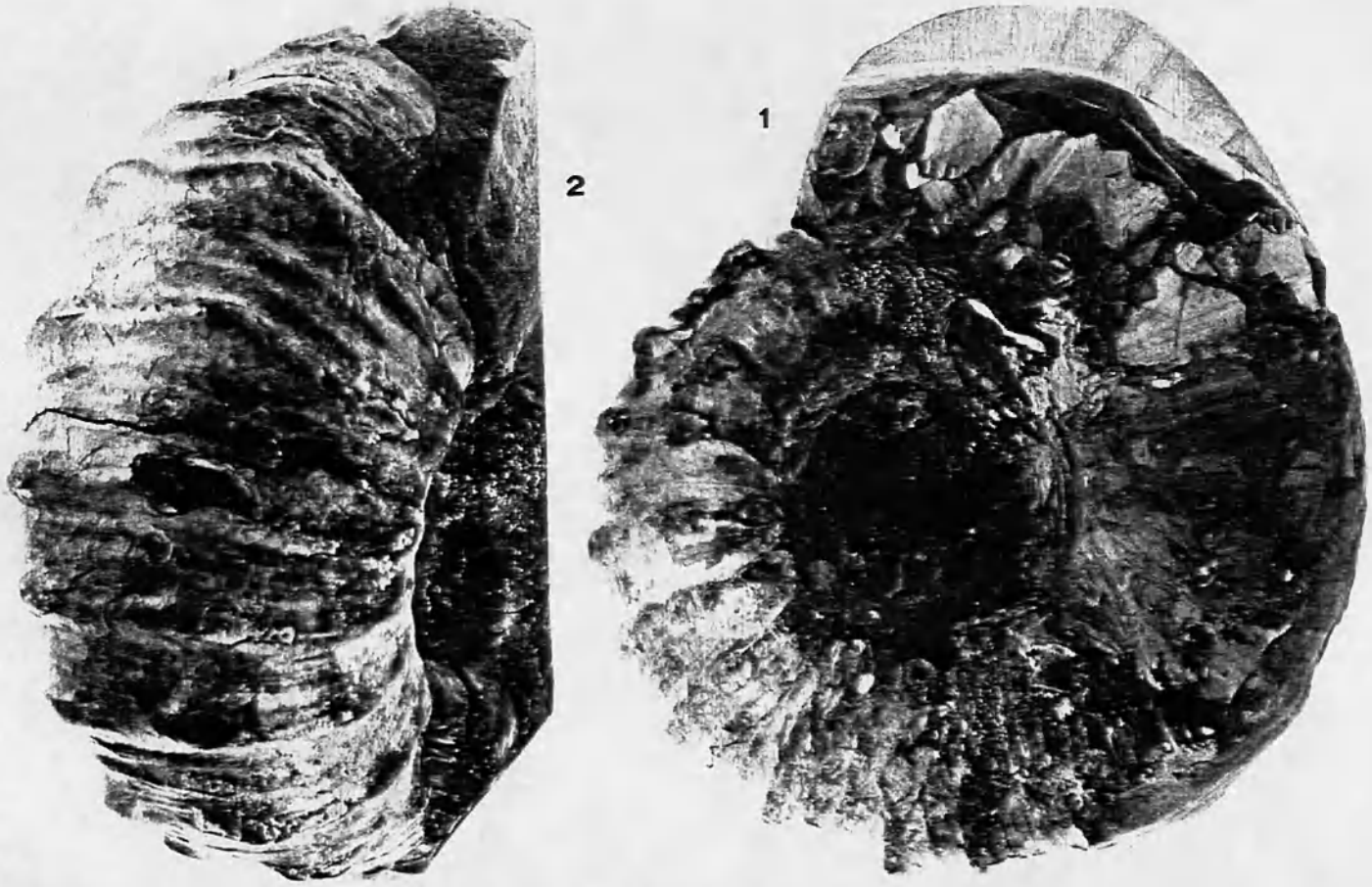
(5–7) *Sonneratia perrinsmithi* nov. (5) Holotype. Greatest diameter, 100 mm.; thickness of whorl, 32 mm. (6, 7) Smaller examples of the same species from the type locality. Perrin zone, upper part of the Horsetown Group; Loc. 152 (C. A. S.), east branch of Hulen Creek, Shasta County. p. 194.



CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 52.—CRETACEOUS FOSSIL FROM CALIFORNIA

Cheloniceras bradleyi nov. Holotype. Size reduced. Greatest diameter, 155 mm.; thickness of whorl, 85 mm. Bradley zone, upper part of the Horsetown Group; Loc. 159 (C. A. S.), near head of the east branch of Hulen Creek, Shasta County. p. 177.



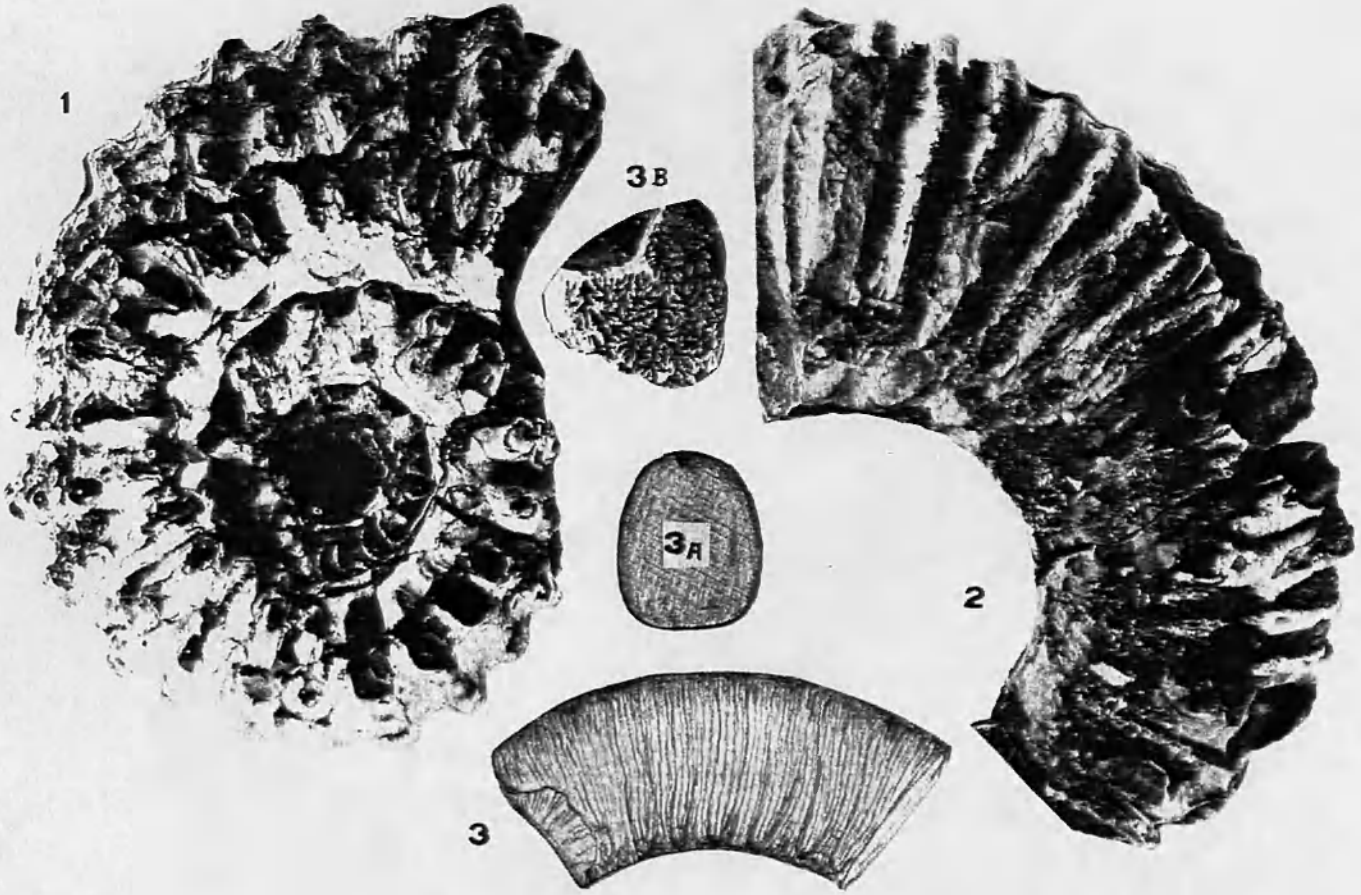
CRETACEOUS FOSSIL FROM CALIFORNIA

PLATE 53.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1) *Douvilleiceras aurarium* nov. Holotype, a little enlarged. Greatest diameter, 85 mm.; thickness of whorl, 35 mm. Bradley zone, upper part of the Horsetown Group; near head of the east branch of Hulen Creek, Shasta County. p. 175.

(2) *Cheloniceras populorum* nov. Holotype. Greatest diameter (est.), 160 mm.; thickness of whorl (est.), 90 mm. Length of fragment on the periphery, 200 mm. Bradley zone, upper part of Horsetown Group; Cottonwood Creek, 1.5 miles above the mouth of Hulen Creek, Shasta County. p. 177.

(3, 3a, 3b) *Hoplocrioceras onoense* nov. (*See* Pl. 61). (3, 3a) Drawn from holotype. (3b) Suture line from holotype (Pl. 61). p. 202.



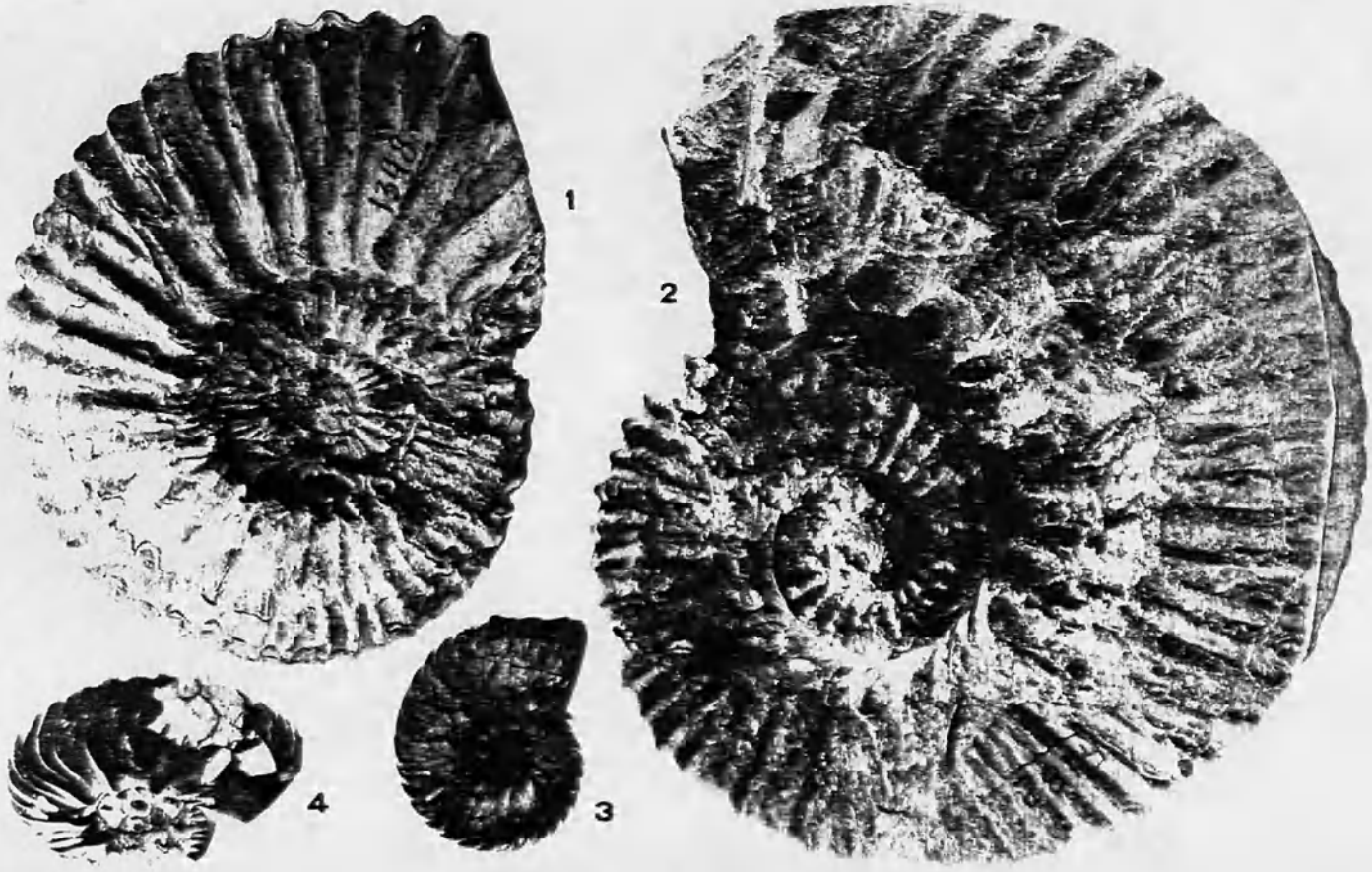
CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 54.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1) *Acanthoplites gardneri* nov. Paratype. Greatest diameter, 95 mm.; thickness of whorl, 36 mm. A little above the Argonaut zone, upper middle Horsetown Group; Loc. 1348 (C. A. S.), on Alderson Creek, 2 miles south of Ono, Shasta County. p. 172.

(2) *Douvilleiceras restitutum* nov. Holotype. Greatest diameter, 153 mm.; thickness of whorl (est.), 75 mm. Upper beds of the Horsetown Group; Loc. 1344 (C. A. S.), old Horsetown, Shasta County. p. 175.

(3, 4) *Sonneratia mulleri* nov. (3) Paratype. Diameter 38 mm. (4) Plesiotype. Perrin zone of Hulen beds, Hulen Creek. p. 195.



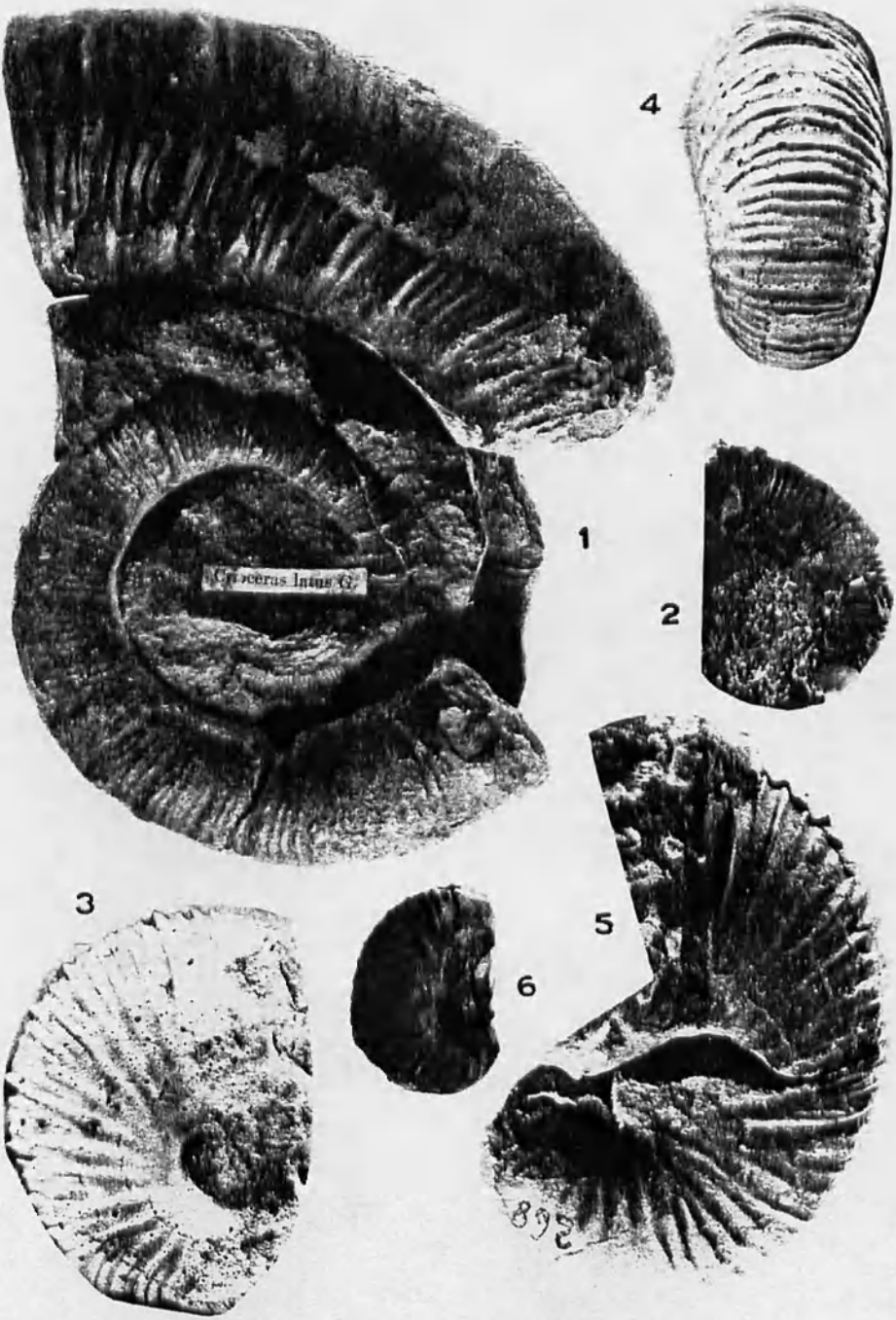
CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 55.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1) *Crioceras latum*. Gabb. Holotype. Greatest diameter of whorl, as figured, 125 mm.; thickness of whorl, 39 mm. Holotype from the Museum of Paleontology, University of California. Upper part of Paskenta Group; probably from near Loc. 1691 (C. A. S.), Clements ranch, Trinity County. p. 200.

(2) *Crioceras dunconense* nov. Holotype. A fragment of an inner coil. Greatest diameter, 38 mm.; thickness of whorl, 11mm. Middle part of the Paskenta Loc. 1665 (C. A. S.), Duncan Creek, Shasta County. p. 200.

(3-6) *Phylloceras trinitense* nov. (3, 4) Plaster cast of holotype. Greatest diameter, 52 mm.; thickness of whorl, 24 mm. Upper part of the Paskenta Group; Loc. 1691 (C. A. S.), Clements Ranch, Redding Creek, Trinity County. (5, 6) Examples from near Riddle, Oregon. Probably upper part of the Paskenta Group. (5) Mature shell. (6) Young shell of same species. p. 140.

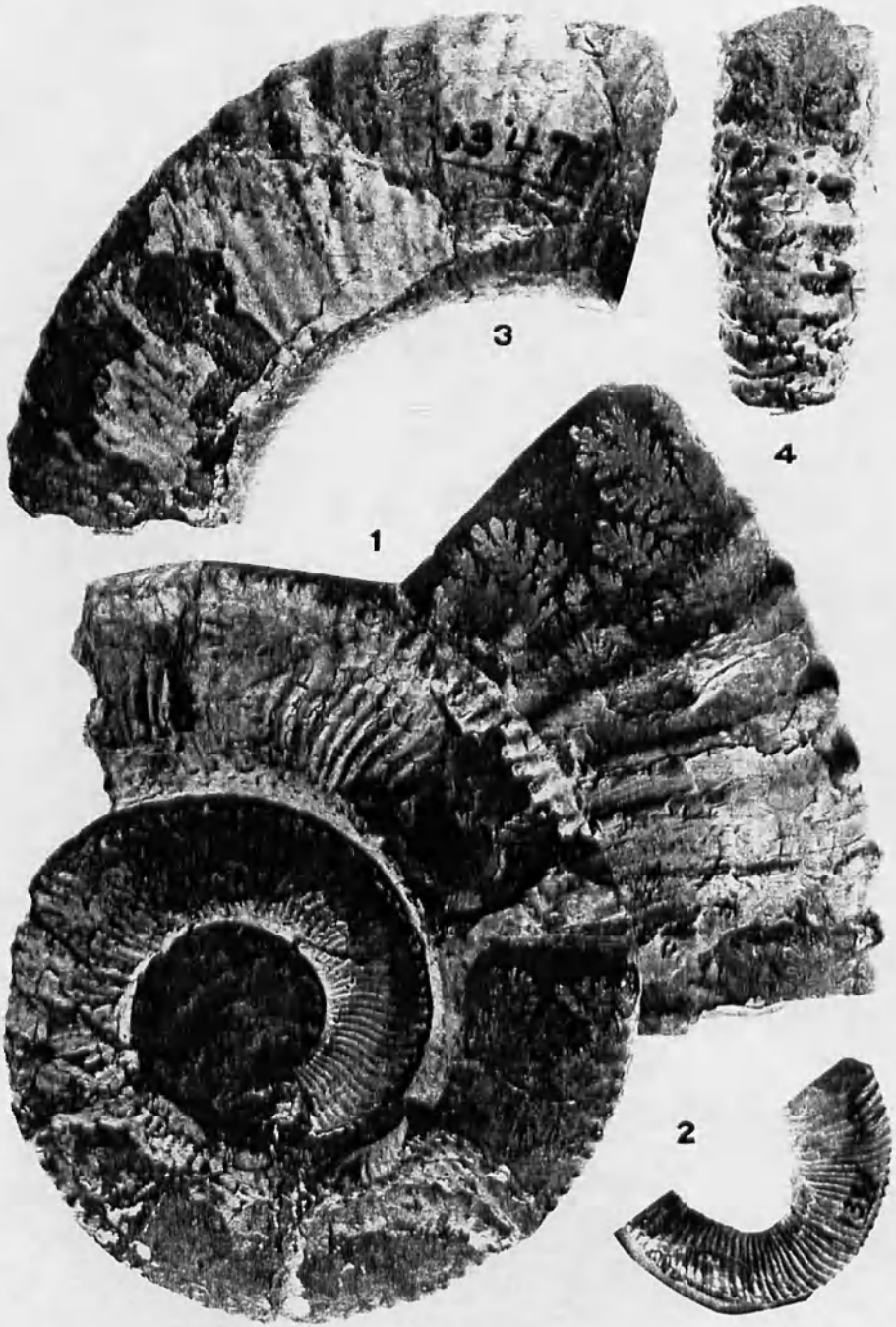


CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 56.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1) *Shastiricoceras hesperum* nov. Holotype. Greatest diameter (of coiled portion), 127 mm.; height of body-chamber, 60 mm.; greatest thickness of same, 40 mm. Mitchell zone, lower part of Horsetown Group; near Loc. 1661 (C. A. S.), south of Roaring River, Shasta County. (2) Fragment of small example. Near Ono, Shasta County. Lower part of Horsetown Group. p. 204.

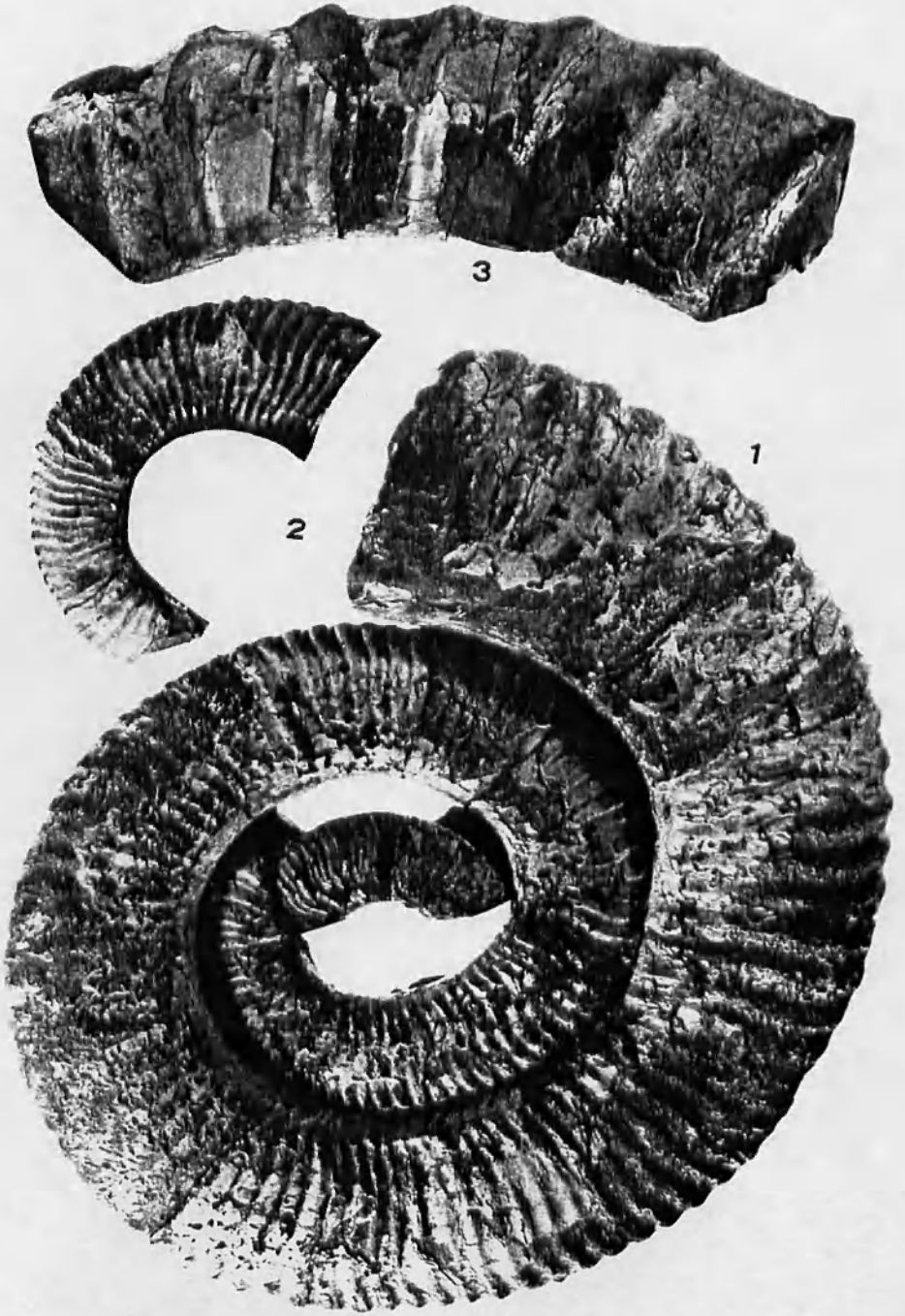
(3, 4) *Shastiricoceras inflatum* nov. Holotype. Length of fragment (measured on periphery), 135 mm.; thickness of whorl, 33 mm. (4) Small fragment of same, showing the siphonal zone. p. 205.



CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 57.—CRETACEOUS FOSSIL FROM CALIFORNIA

Shastiricoceras ponienie nov. (1) Holotype. Greatest diameter, 225 mm.; thickness of whorl, 45 mm. (2) Fragment of small example, showing character of ribbing. Greatest diameter, 54 mm.; thickness of whorl, 13 mm. (3) Paratype. Fragment of straightened arm, much reduced in size. Total length, 295 mm.; thickness of arm (including ribs), 60 mm. All from Mitchell zone, lower part of Horsetown Group; Loc. 1657 (C. A. S.), Mitchell Creek, Shasta County. p. 204.



CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 58.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1) *Shasticrioceras whitneyi* nov. Holotype. Greatest diameter (est.), 120 mm.; height of whorl, 30 mm.; thickness of whorl, 19 mm. Mitchell zone, lower part of Horsetown Group; Loc. 1347 (C. A. S.), Mitchell Creek, Shasta County, 6 miles south of Ono. p. 205.

(2, 2a) *Hamulina aldersona* nov. Holotype, slightly enlarged. Length of smaller arm, 110 mm.; thickness of larger arm, 20 mm. About 200 feet above the Argonaut zone, Horsetown Group; near Loc. 1348 (C. A. S.), Alderson Creek, Shasta County. (2a) First lateral lobe of suture line, near top of smaller arm. p. 219.

(3) Suture line of *Hemibaculites cyclopius*, taken from holotype. p. 221.

(4) Section of *Shasticrioceras inflatum* nov. (*See* Pl. 56, fig. 3.) p. 205.

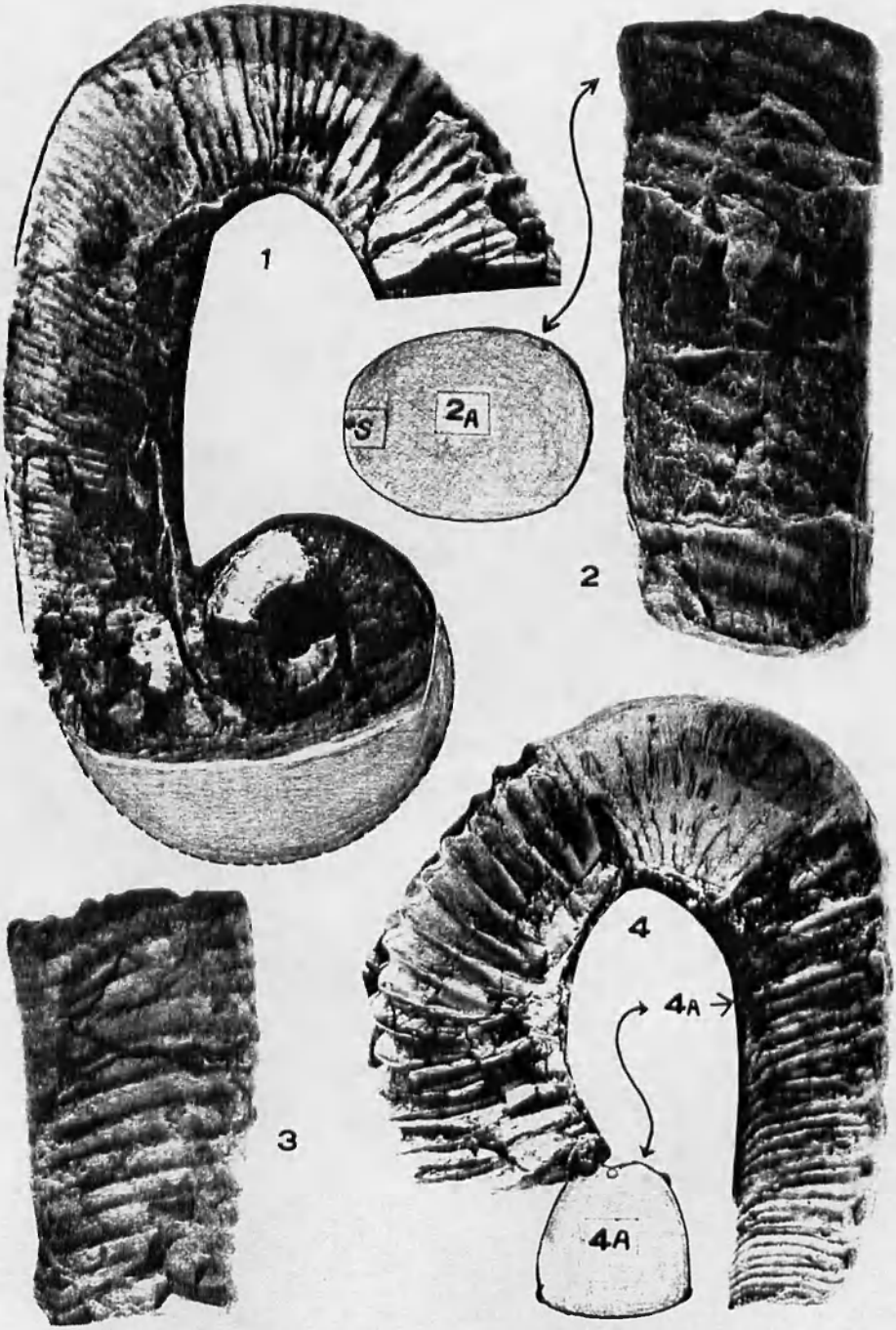
CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 59.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1) *Acrioceras voyanum* nov. Holotype. Length of shell (incomplete), 95 mm.; width of crosier, 69 mm.; thickness of body-chamber, 24 mm. Lower part of Horsetown Group; probably from, or just above, the Ono zone, Cottonwood Creek, Shasta County. p. 206.

(2, 2a, 3) *Hemibaculites neleus* nov. (2) Holotype, a little enlarged, length 81 mm.; greater diameter, 33 mm. Mitchell zone, lower part of Horsetown Group; Loc. 1657 (C. A. S.), near Mitchell Creek, Shasta County. (2a) Section of shaft. (3) Fragment of an example from a somewhat lower bed; lower Horsetown Group; Loc. 1661 (C. A. S.), south of Roaring River, Shasta County. p. 221.

(4) *Acrioceras starrkingi* nov. Holotype (partly restored). A little below Mitchell zone, lower part of Horsetown Group; Loc. 1661 (C. A. S.), south of Roaring River, Shasta County. (4a) Cross section of (4) at point indicated. Natural size. p. 207.

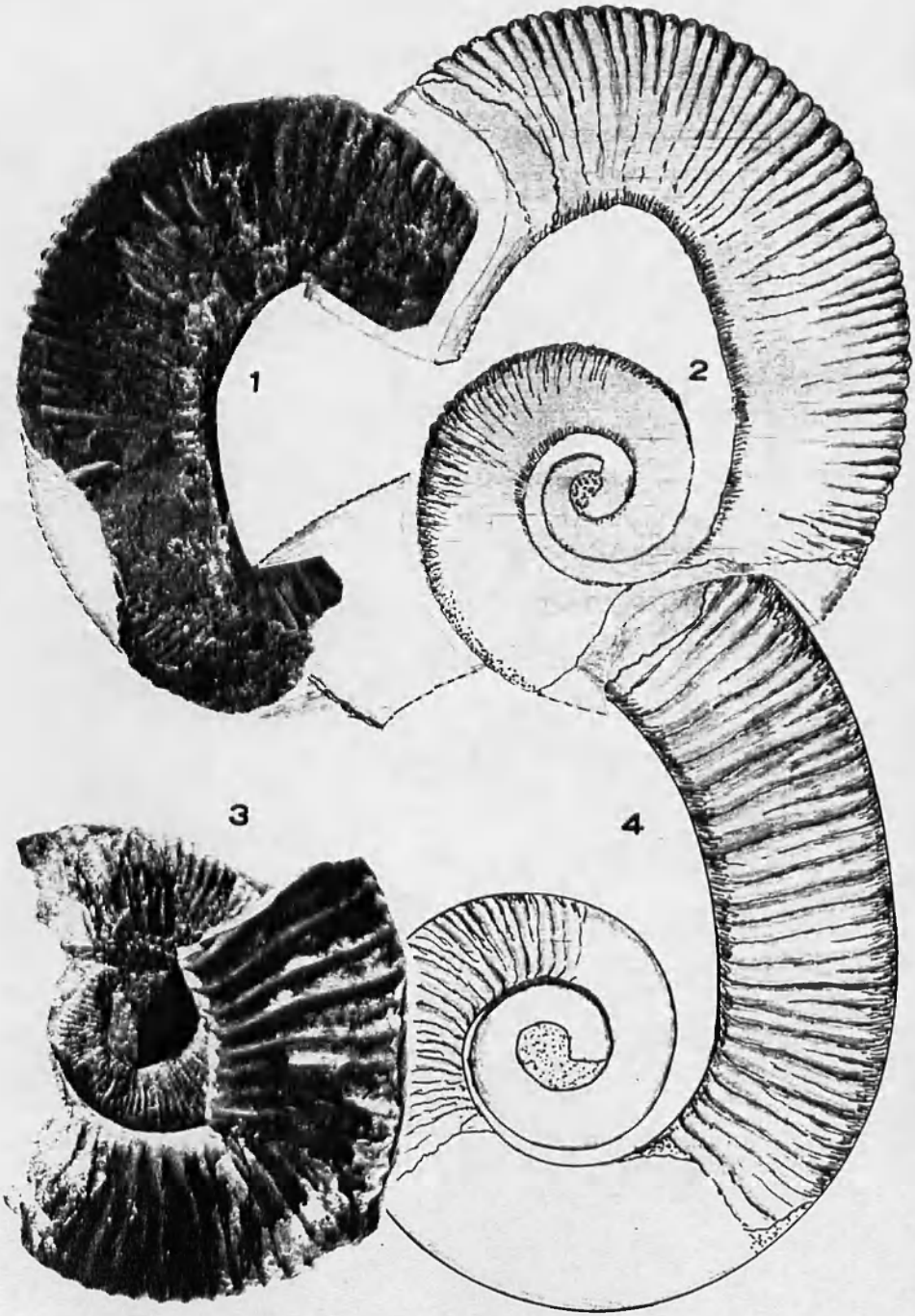


CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 60.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1, 2) *Aspinoceras hamlini* nov. (1) Holotype. Length of shell (incomplete), 86 mm.; maximum thickness, 27 mm. Hamlin—Broad zone, upper part of Paskenta Group; Loc. 113 (C. A. S.), 4 miles southwest of Ono, Shasta County. (2) Drawing of same, showing form indicated in holotype. p. 207.

(3, 4) *Hoplocrioceras wintunium* nov. (3) Part of holotype as found. Greatest diameter of coiled portion, 45 mm.; thickness of same, 8 mm. (4) Drawing made from holotype, showing more complete form, as indicated in holotype. Stratigraphic position a little below the Mitchell zone, lower Horsetown Group; Loc. 1661 (C. A. S.), south of Roaring River, Shasta County. p. 202.



CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 62.—CRETACEOUS FOSSILS FROM CALIFORNIA AND OREGON

(1–5) *Hoplocrioceras remondi* (Gabb). (1) Holotype, from Academy of Natural Sciences, Philadelphia. Greatest diameter, 77 mm.; thickness of whorl, 18 mm. Probably from Ono zone, lower beds of Horsetown Group; near Ono. (2) *Hoplocrioceras remondi*, nov. Example found in place, Eagle Creek, near Ono. (3, 5) Same species, from collections in the Academy of Natural Sciences, Philadelphia. Probably from the Ono zone, near Ono, Shasta County. (4) Fragment of same species, from Loc. 1665 (C. A. S.), Duncan Creek, Shasta County. p. 201.

(6) *Hoplocrioceras remondi* (Gabb). Fragment, found at Loc. 268 (O. A. C.), near Riddle, Oregon. (2a) Section of example seen in Figure 2. p. 201.

CRETACEOUS FOSSILS FROM CALIFORNIA

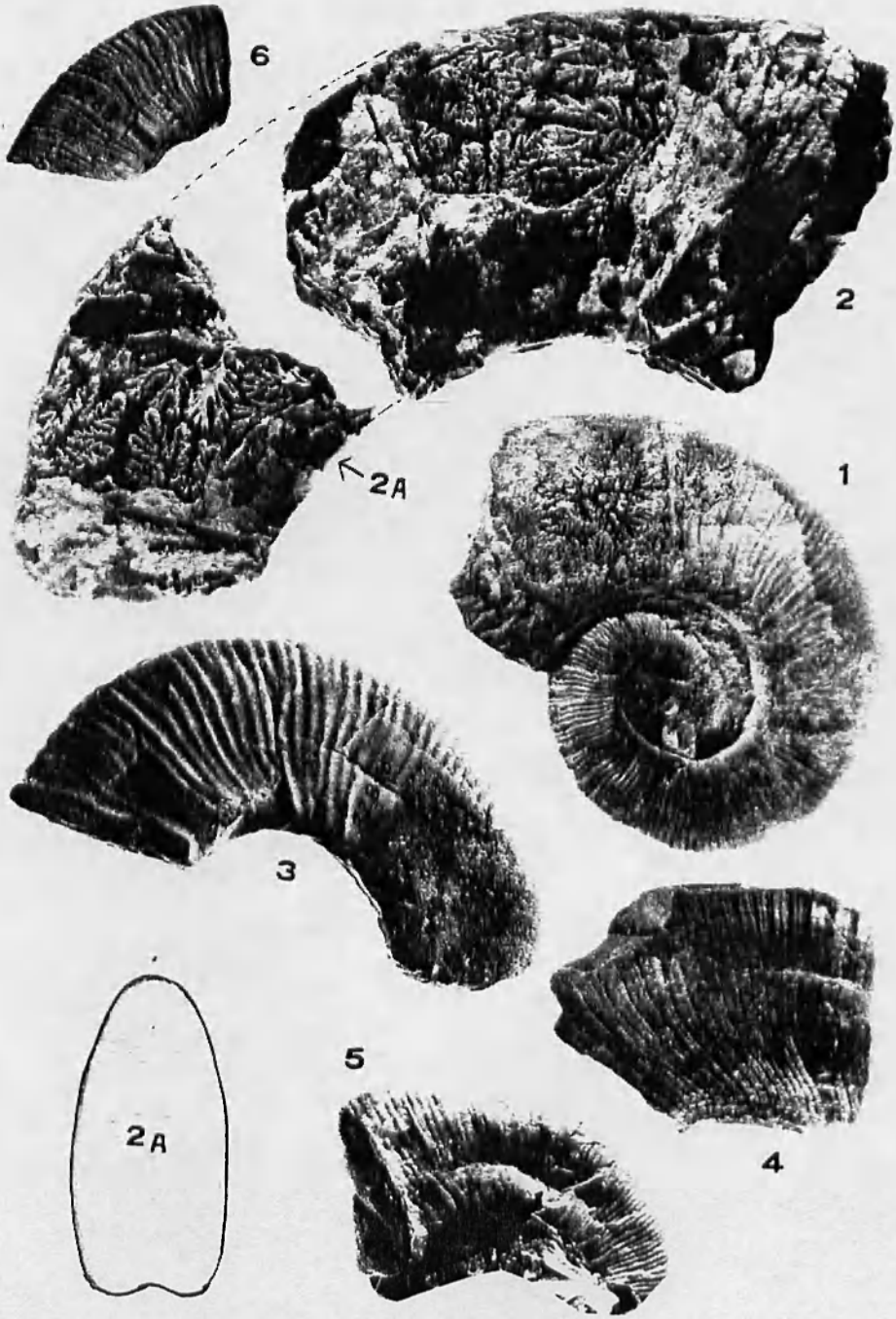
PLATE 61.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1, 1a) *Pseudocrioceras stentor* nov. Holotype. Length along siphonal zone, 250 mm.; greatest diameter, 55 mm.; diameter at smaller end, 27 mm. (Note fragment of smaller coil, displaced.) Found 200 feet below Mitchell zone, lower part of Horsetown Group; Loc. 1661 (C. A. S.), south of Roaring River, Shasta County. p. 206.

(2) *Ptychoceras natrice* nov. Holotype. Length 52 mm.; width across both arms, 23 mm. Mitchell zone, lower part of Horsetown Group; Loc. 1657 (C. A. S.), north of Roaring River, Shasta County. p. 218.

(3, 3a) *Pseudocrioceras* sp. (3a) Reflected end view. p. 206.

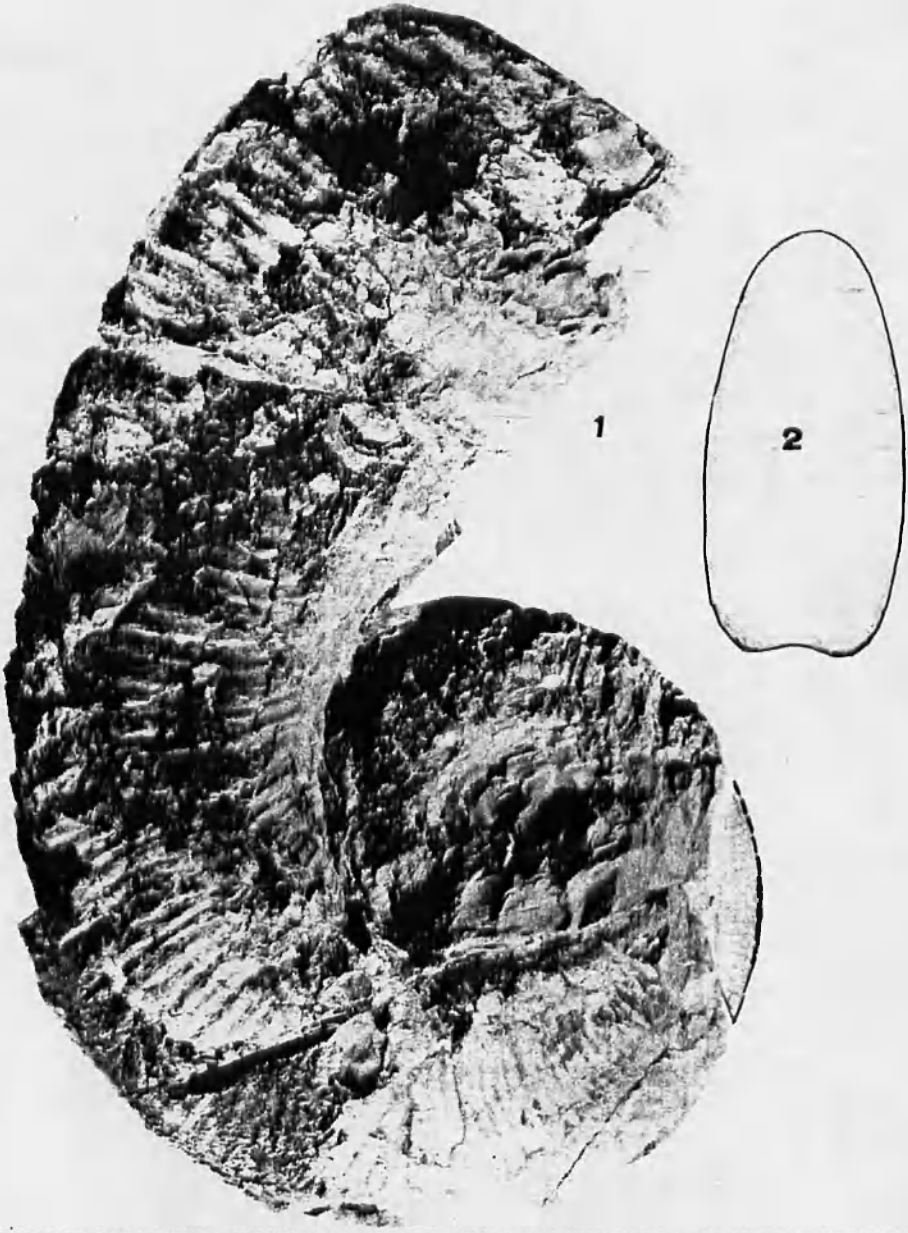
(4) *Hoplocrioceras onoense* nov. Holotype. Natural size. Found on Eagle Creek, near Ono, Shasta County. (*See* Pl. 53.) p. 202.



CRETACEOUS FOSSILS FROM CALIFORNIA AND OREGON

PLATE 63.—CRETACEOUS FOSSIL FROM CALIFORNIA

Hoplocrioceras remondi (Gabb). (1) Large example, showing mature form, straightened arm, change of ribbing, etc. (2) Section of same, near bucal end. Length of specimen, 225 mm. Upper middle Horsetown Group; east of Mitchell Creek, Shasta County. p. 201.



CRETACEOUS FOSSIL FROM CALIFORNIA

PLATE 64.—CRETACEOUS FOSSIL FROM CALIFORNIA

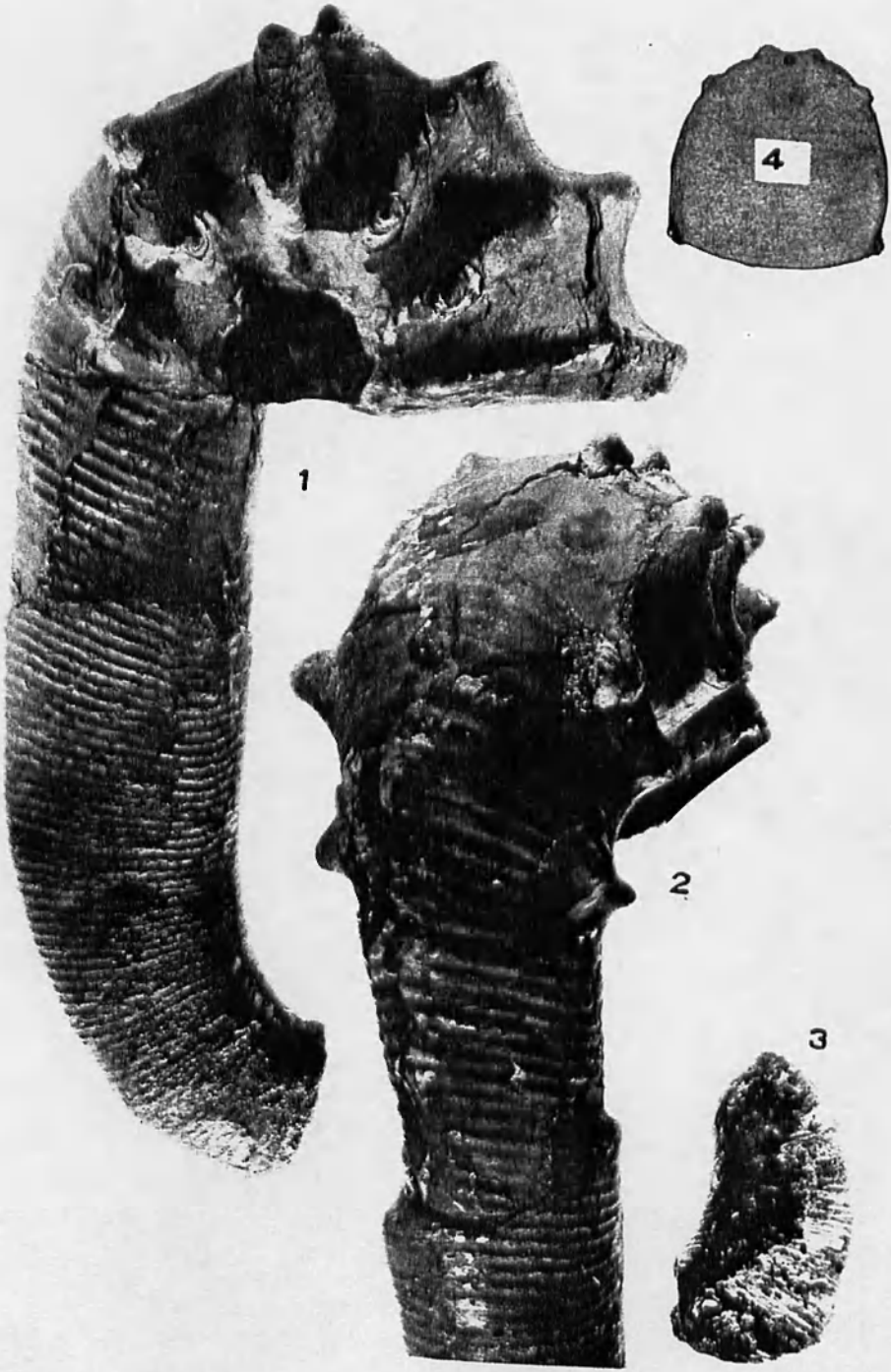
Ancyloceras elephas nov. (1) View showing right side of holotype. (2) Oblique front view of same. Total length, 16.5 inches (419 mm.), incomplete; greatest width (not including spines) 4.25 inches (108 mm.). Mitchell zone, lower part of Horsetown Group; Loc. 1857 (C. A. S.), Mitchell Creek, Shasta County. p. 209. (*See* Pl. 66.)

CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 65.—CRETACEOUS FOSSILS

(1-3) *Ancyloceras ajax* nov. (1) Right side view. Total length of holotype, 14 inches (355 mm.); width of body-chamber, 4 inches (101.6 mm.). Note crushing of shaft during life of animal; all parts of specimen found in place. (2) Oblique front view of same specimen. (3) Fragment of early whorl of another example of the same species, showing tubercules in early stage of growth. p. 210.

(4a) *Acrioceras starkingi* nov. Enlarged section of shaft (smaller arm), as shown on Plate 59, figure 4. p. 207.



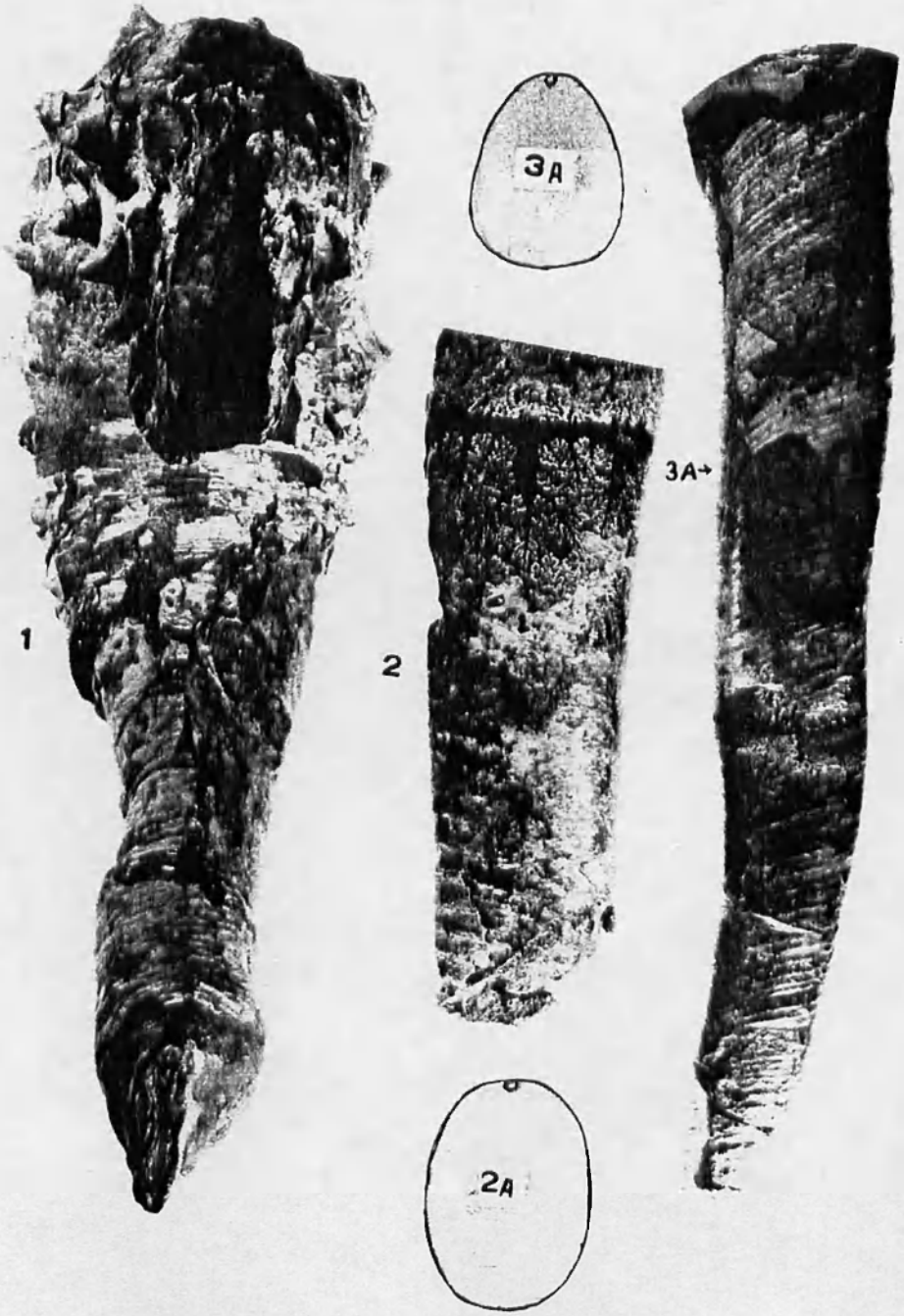
CRETACEOUS FOSSILS

PLATE 66.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1) *Ancyloceras elephas* nov. Holotype. Dorsal view, showing aperture (dark area above the shaft). Note crushing of shaft below body-chamber during life of the animal. (*See* Pl. 64.) p. 209.

(2, 2a) *Hemibaculites nauplius* nov. Holotype. (2) Side view, showing suture line, in part. Length 100 mm.; greatest width, 30 mm. (2a) Section of holotype, near middle. Mitchell zone, lower part of Horsetown Group; Loc. 1347 (C. A. S.), near Mitchell Creek, Shasta County. p. 221.

(3, 3a) *Hemibaculites cyclopius* nov. Holotype. (3) Length of holotype, 15.3 inches (386,6 mm.); greatest diameter, 76 mm. Above the Argonaut zone, upper part of Horsetown Group; Loc. 1348 (C. A. S.), Alderson Creek, 2 miles south of Ono, Shasta County. (3a) Section of same. p. 221.



CRETACEOUS FOSSILS FROM CALIFORNIA

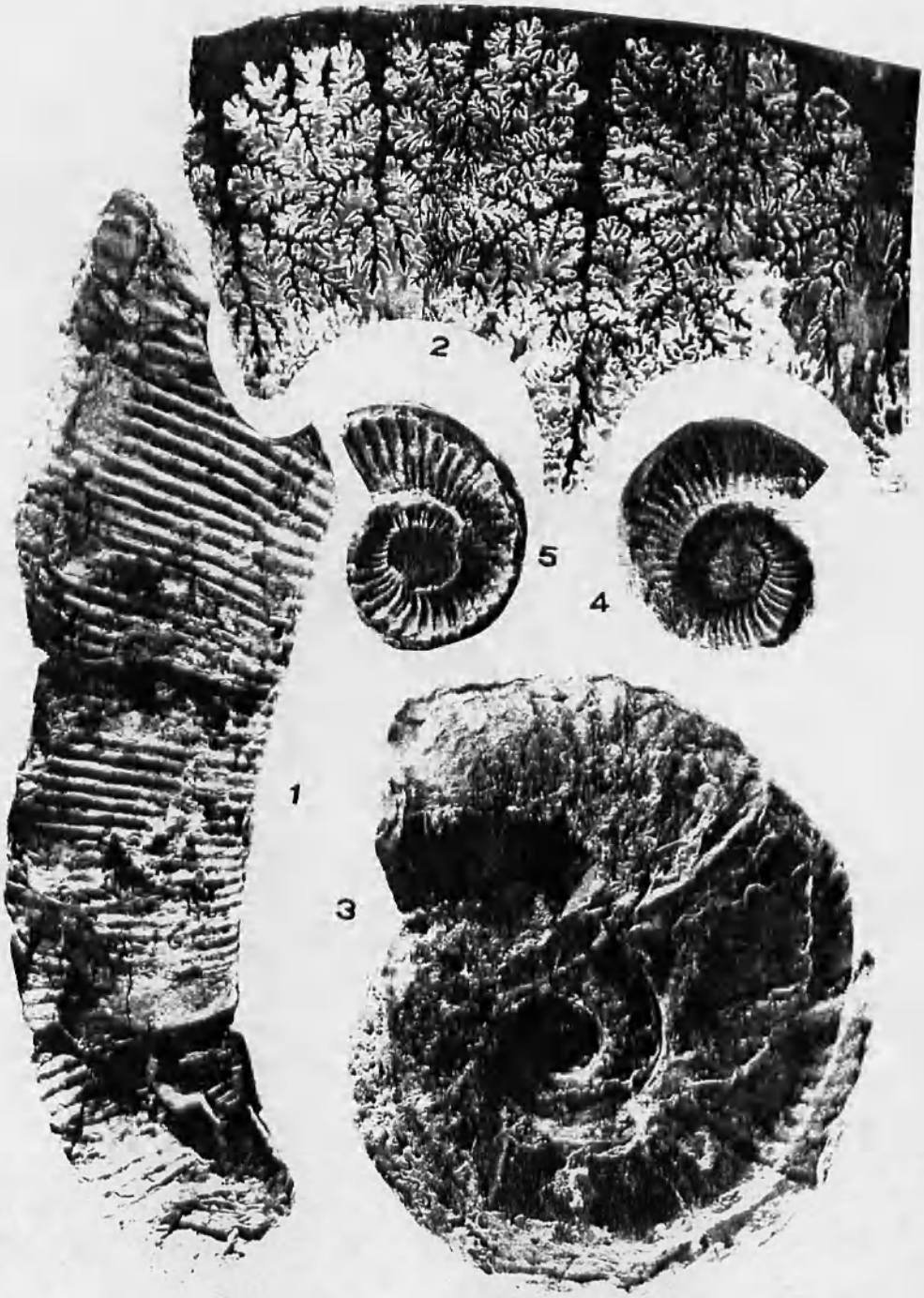
PLATE 67.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1) *Ancyloceras durrelli* nov. Holotype. Total length of figured part of the shaft, 230 mm.; greatest diameter, 63 mm. Found about 200 feet beneath the Mitchell zone, lower part of Horsetown Group; Loc. 1661 (C. A. S.), south of Roaring River, Shasta County, p. 210.

(2) Suture line of *Ancyloceras durrelli*, drawn from a detached fragment found at the same locality and horizon. p. 210.

(3) *Melchiorites indigenes* nov. Plesiotype. Greatest diameter, 92 mm.; thickness of whorl, 25 mm.; apparently a little above the Argonaut zone, upper part of the Horsetown Group; Loc. 1348 (C. A. S.), Alderson Creek, Shasta County. p. 184.

(4, 5) *Shastiorioceras poniente* nov. Small examples from the Mitchell zone, showing the manner of coiling and costation in young stages of growth. p. 204.



CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 68.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1) *Ancyloceras durrelli* nov. Paratype, consisting of the body chamber of an example found with the holotype. Position about 200 feet beneath the Mitchell zone, lower part of the Horsetown Group; Loc. 1661 (C. A. S.), south of Roaring River, Shasta County. p. 210.

(2) *Melchiorites indigenes* nov. Plesiotype. Greatest diameter, 55 mm.; thickness of whorl, 15 mm. Found a little above the Argonaut zone, upper part of the Horsetown Group; Loc. 1348 (C. A. S.), Alderson Creek, 2 miles south of Ono, Shasta County. p. 184.

(3) *Shasticrioceras hesperum* (?), nov. Young coil, showing character of ribbing in early stages of growth. Mitchell zone, lower part of Horsetown Group; Loc. 1657 (C. A. S.), near Mitchell Creek. p. 204.

(4) First lateral lobe of *Neocrospedites aquila* nov. (*See* Pl. 25.) p. 156.

CRETACEOUS FOSSILS FROM CALIFORNIA

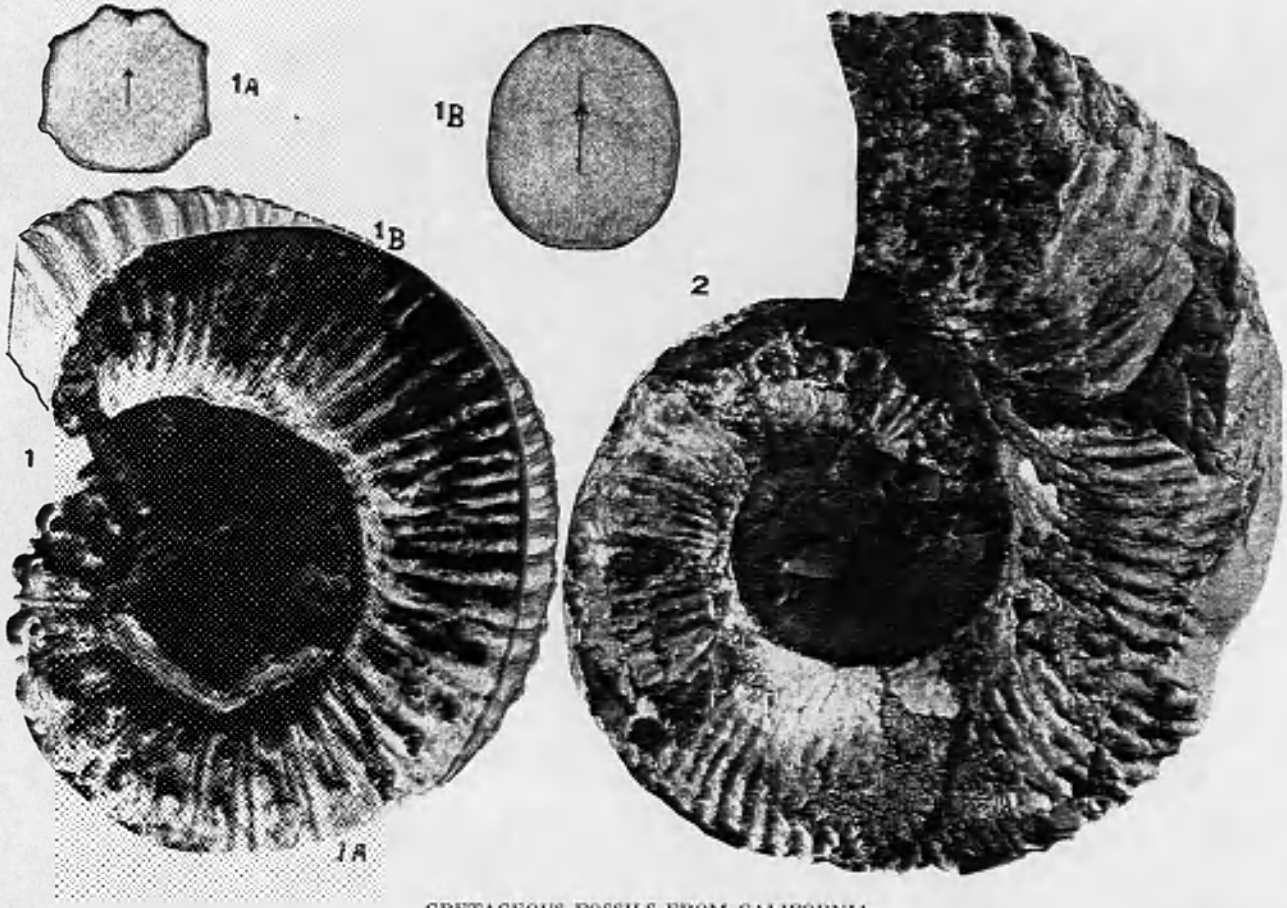
PLATE 69.—CRETACEOUS FOSSIL FROM CALIFORNIA

Ancyloceras attrox nov. Holotype. (1) Left side view, much reduced. (2) Oblique ventral view of holotype, showing strong, trituberculate ribs on the body chamber. Length of holotype along siphonal line, 230 mm.; greatest width of body chamber, 88 mm.; greatest diameter at top of shaft, 70 mm. (3) Section of body chamber below bend. (3a) Section of shaft at end of figured fragment. Mitchell zone, lower part of Horsetown Group; a mile north of Loc. 1347 (C. A. S.), east of Mitchell Creek, Shasta County. p. 209.

CRETACEOUS FOSSIL FROM CALIFORNIA

PLATE 70.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1, 1a, 1b, 2) *Australiceras argus* nov. Holotype. (1) Left side view, showing tubercules on early part of whorl. (1a) Section of tuberculate portion of whorl. (1b) Section of non-tuberculate portion of whorl, at A. A little below Argonaut zone on Bee Creek. (2) Paratype. Greatest diameter, 154 mm.; thickness of whorl, 44 mm. Tuberculate on inner whorls, only. Larger whorl broken and slightly displaced. Below Argonaut zone, between Bee Creek and Roaring River, east of Mitchell Creek, Shasta County. p. 211.



CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 71.—CRETACEOUS FOSSIL FROM CALIFORNIA

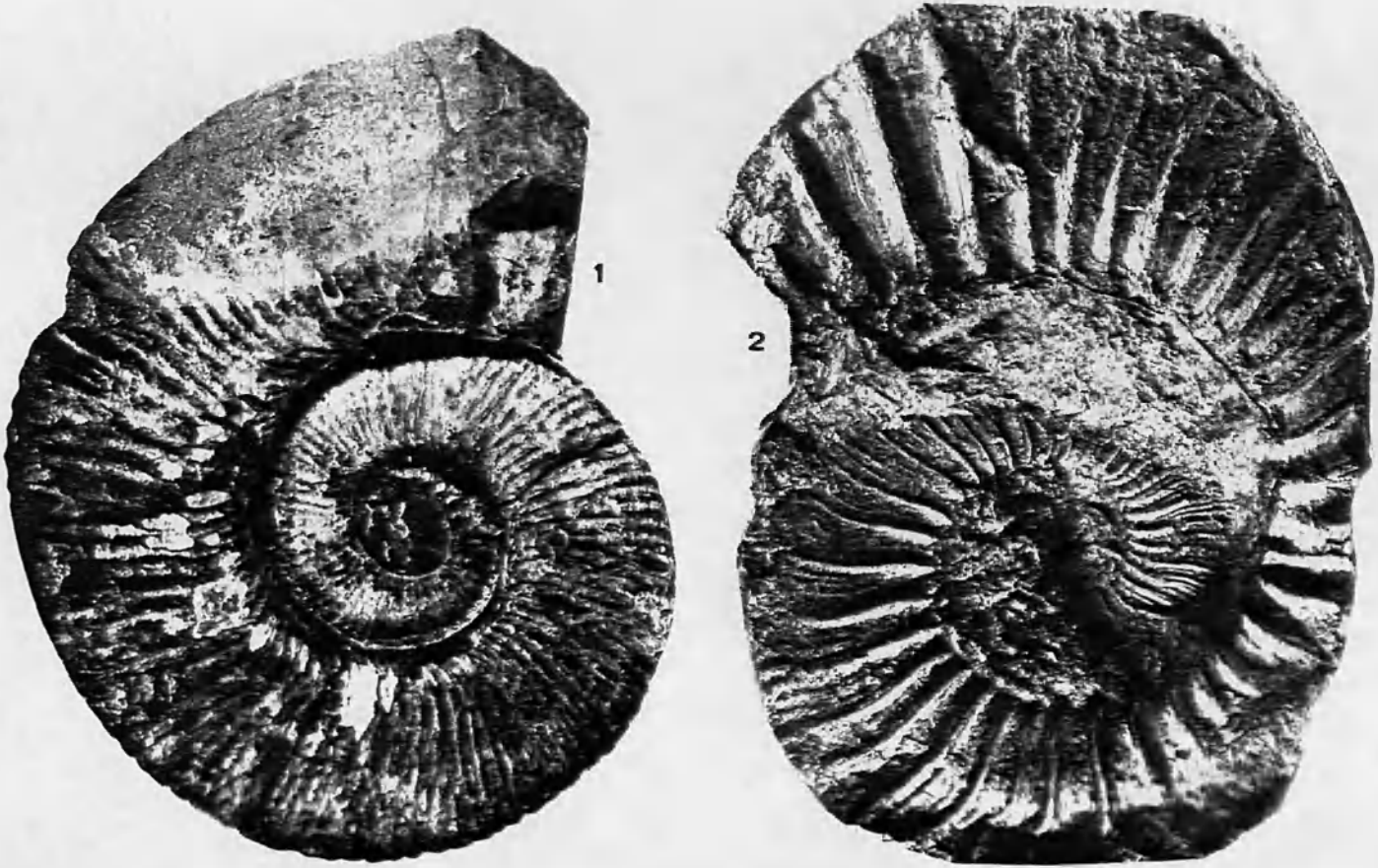
Tropaeum percostatum (Gabb). Large example, showing change in ribbing and other features from youth to old age. Much reduced in size. Greatest diameter, 17 inches (432 mm.). A little above the Argonaut zone, upper middle part of Horsetown Group; near Loc. 1347 (C. A. S.), east of Mitchell Creek, Shasta County. p. 212.

CRETACEOUS FOSSIL FROM CALIFORNIA

PLATE 72.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1) *Tropaeum percostatum* (Gabb). Plesiotype. Young example, septate throughout. Some reduced in size. Greatest diameter, 130 mm.; thickness of whorl, 30 mm. Near Argonaut zone, east of Mitchell Creek, and a mile north of Loc. 1347 (C. A. S.), Shasta County. p. 212.

(2) *Hoplocrioceras yollabollium* nov. Holotype, consisting of a plaster cast, made from a rock mold. Upper part of Paskenta Group; Browns Creek, Trinity County. Greatest diameter, about 220 mm. p. 203.



CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 73.—CRETACEOUS FOSSILS

(1, 2) *Pulchellia popenoei* nov. Holotype. (1) Greatest diameter, 57 mm.; thickness of whorl, 17 mm. Stratigraphic position, a little below the Mitchell zone, Horsetown Group, Roaring River district. Holotype found by W. P. Popenoe and D. W. Scharf, Loc. 967 (C. I. T.). (2) Front view of holotype, showing the periphery and flattened ventral zone. p. 197.

(3) *Shastoceras shastense* nov. Part of holotype, showing the noded periphery of the coiled portion, and a dorsal view of the same. p. 213.

(4, 5) *Parahoplites scharfi*, nov. Holotype. (4) Side view. Greatest diameter, (across more complete whorl), 85 mm.; thickness of whorl, 36 mm. (5) Rear view of holotype, showing opposite side and rear view and curvature of the ribs. p. 170.

CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 74.—CRETACEOUS FOSSIL FROM CALIFORNIA

Shastoceras californicum nov. Holotype. Total length, 17.5 inches (445 mm.); width of crosier, 10 inches (254 mm.). Probably a little above the Argonaut zone, upper middle Horsetown Group; Cottonwood district, Shasta County. p. 213.

CRETACEOUS FOSSIL FROM CALIFORNIA

PLATE 75.—CRETACEOUS FOSSIL

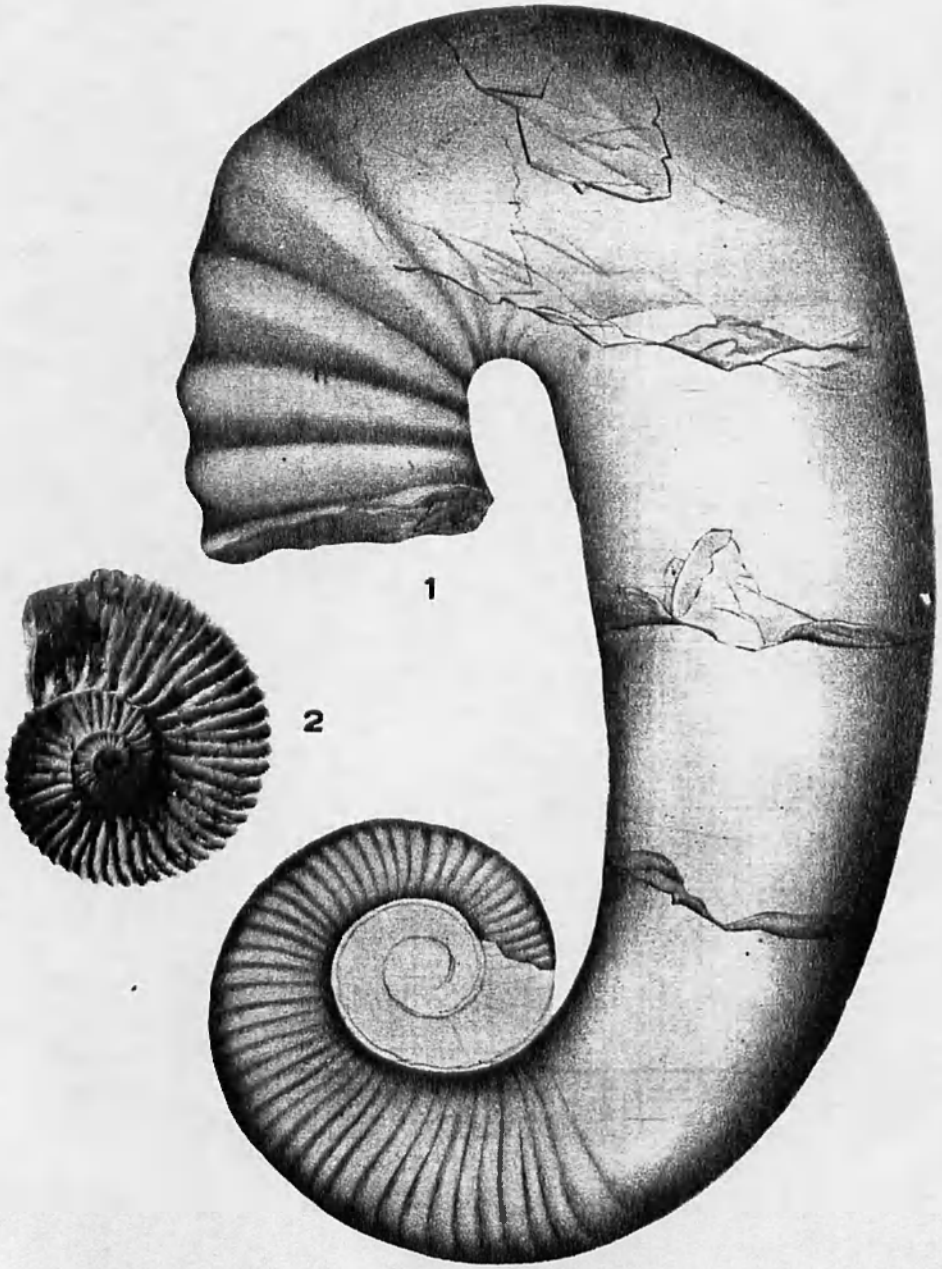
Shastoceras shastense, nov. Holotype. Greatest length, 18.5 inches; width of coil, 11 inches. The figured specimen is in the collections of the California Institute of Technology. It was found by W. P. Popence and D. W. Scharf on Roaring River, just beneath the Barr zone, half a mile east of the Millsap road. p. 213.

CRETACEOUS FOSSIL FROM CALIFORNIA

PLATE 78.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1) *Shastoceras behemoth* nov. Holotype (not yet found). Total length, apparently near 31 inches (787 mm.). Stratigraphic position probably a little above the Argonaut zone, upper middle part of the Horsetown Group; Cottonwood district, Shasta County. p. 214.

(2) *Acanthoplites sub-bigoti* nov. Holotype. Greatest diameter, 40 mm.; thickness of whorl, 13 mm.; Cottonwood Creek, Loc. 965 (C. I. T.). Holotype in the collection of the California Institute of Technology. p. 174.



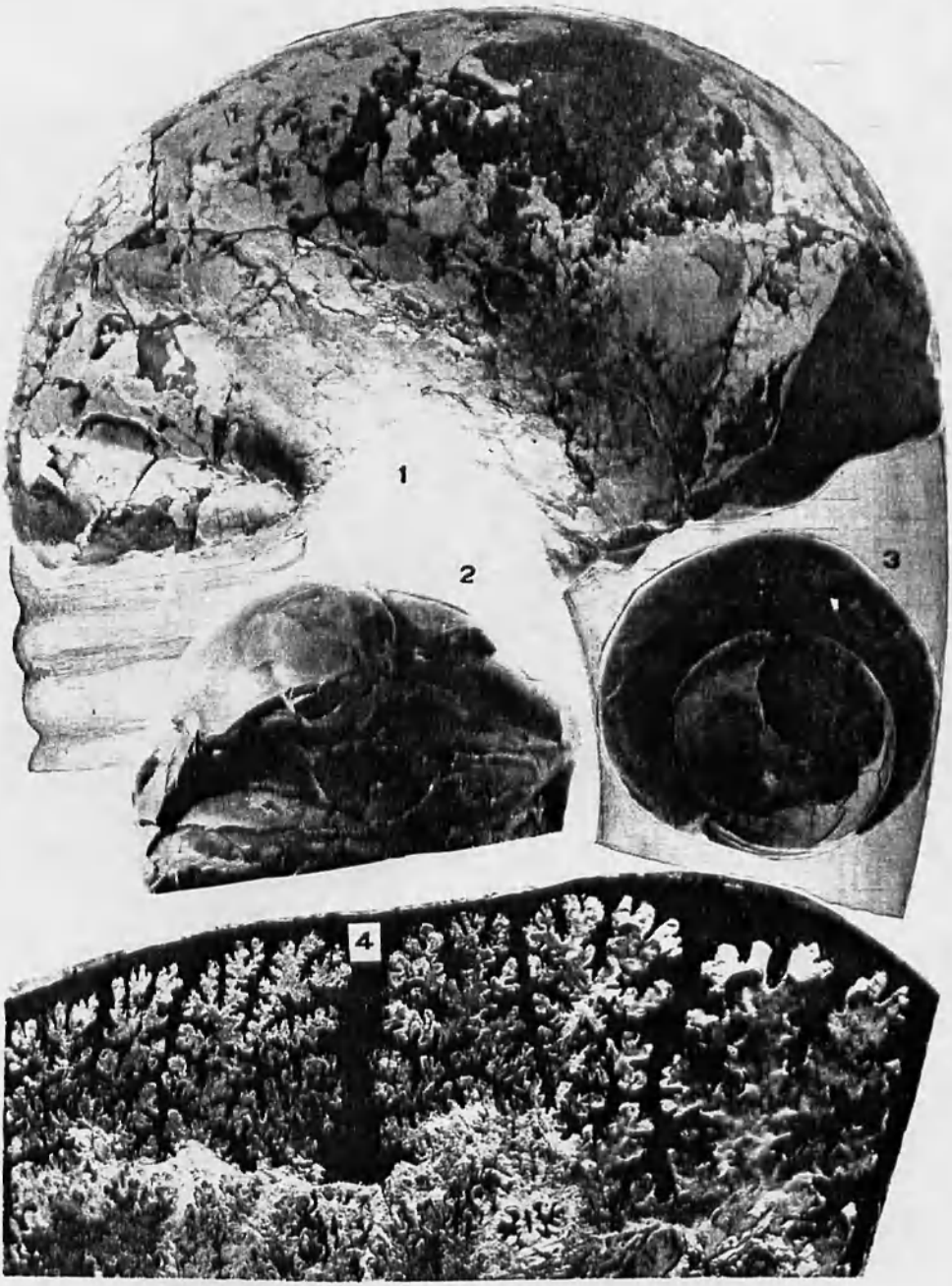
CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 77.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1) *Shastoceras ventricosum* nov. Holotype. Maximum circumference of body chamber at bend, 20.3 inches (515 mm.); maximum diameter, 6.6 inches. Found a little above the Argonaut zone, upper middle part of Horsetown Group; west branch of Hulen Creek, Shasta County. p. 215.

(2, 3) *Belemnoteuthis pacifica* nov. (2) Holotype, showing the edges and an oblique view of the septa. Greatest diameter, 76 mm.; a small part only of a complete phragmacone. Loc. 113 (C. A. S.), Hamlin-Broad zone, Upper part of the Paskenta Group, 4 miles southwest of Ono, Shasta County. (3) Top view of plesiotype. Upper part of Argonaut zone; Loc. 1347 (C. A. S.), middle part of the Horsetown Group, east of Mitchell Creek, Shasta County. p. 231.

(4) Suture line of *Shastoceras behemoth* nov. drawn from a fragment found above the Argonaut zone, west branch of Hulen Creek, Shasta County. p. 214.



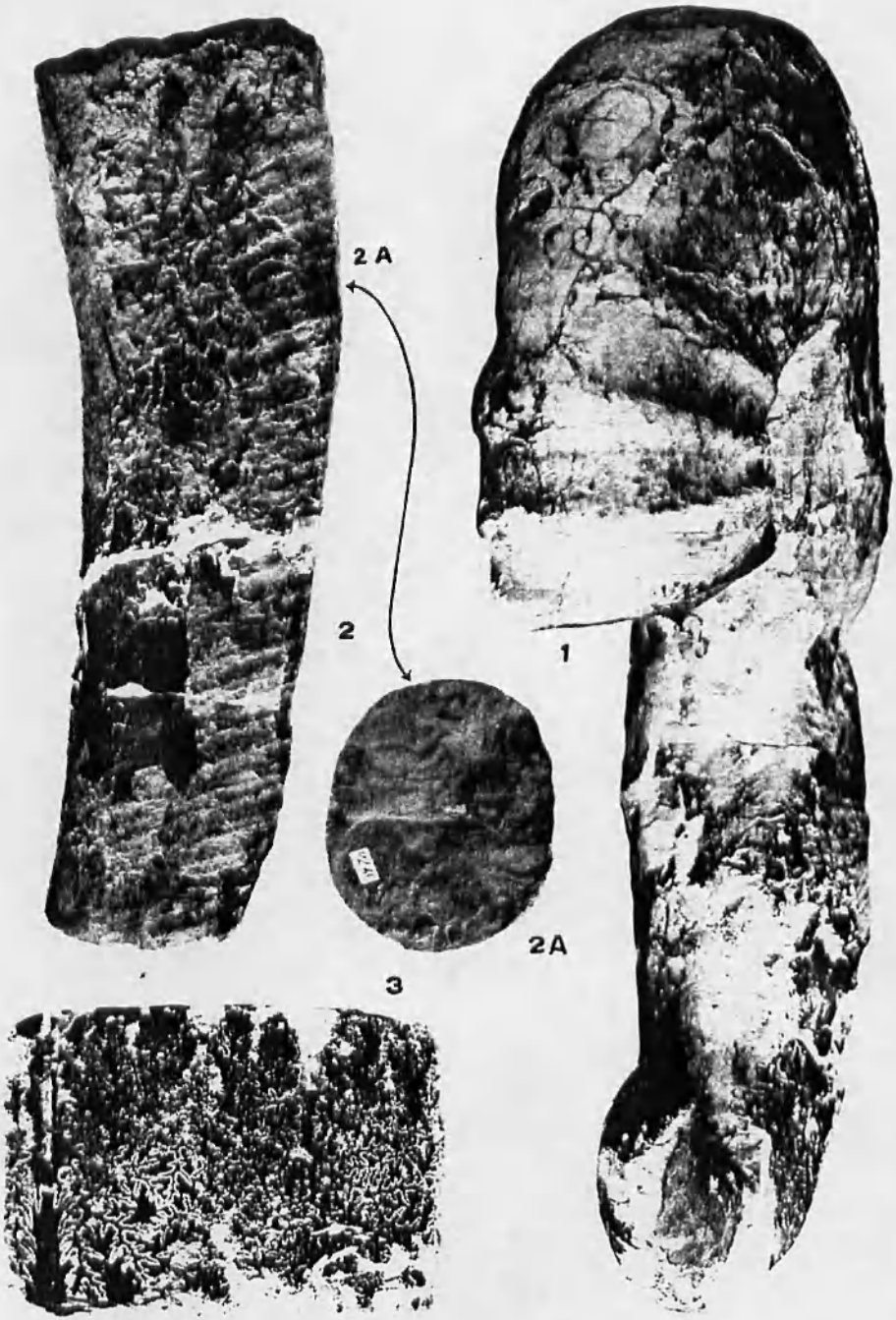
CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 78.—CRETACEOUS FOSSILS

(1) *Shastoceras californicum* nov. Front view of holotype (pl. 74). (Note partial crushing of shaft below body chamber.) p. 213.

(2, 2a) *Hemibaculites mirabilis* nov. Holotype. (Example figured by Gabb not found.) Found by W. P. Popenoe and D. W. Scharf near Mitchell Creek, half a mile north of Roaring River, and half a mile east of the Jordan house, 6 miles south of Ono, Shasta County. (2a) Cross section of (2) at point indicated. Property of the California Institute of Technology, Pasadena. p. 220.

(3) Suture line of *Hemibaculites mirabilis*, nov. taken from an example found in the same zone as the holotype, 100 feet above the zone of *Tropaeum percostatum* (Gabb). p. 220.



CRETACEOUS FOSSILS FROM CALIFORNIA

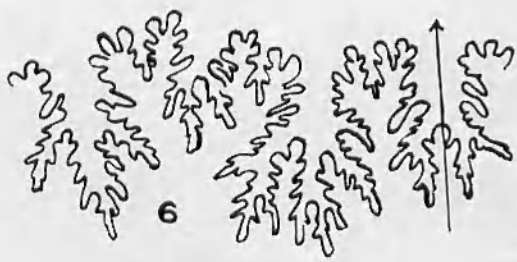
PLATE 79.—CRETACEOUS FOSSILS

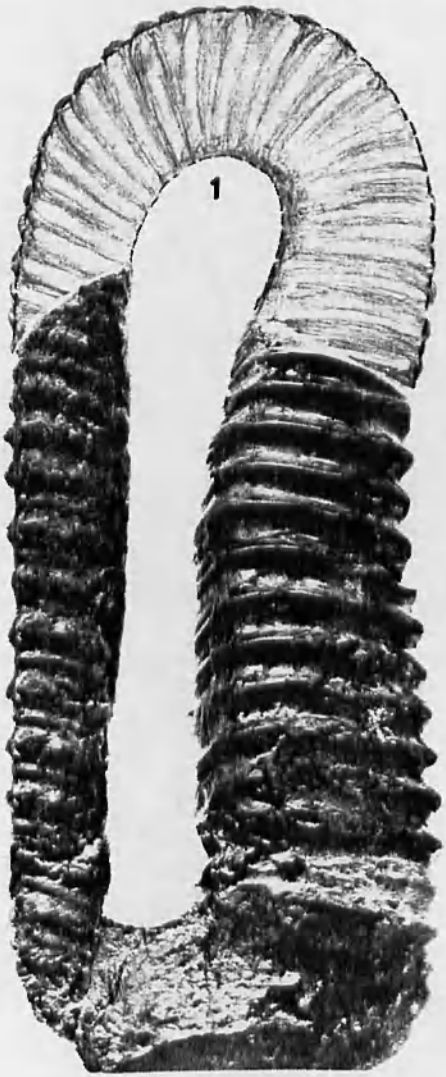
(1) *Hamiticeras pilsbryi* nov. Holotype. Total length, 92 mm.; maximum diameter of larger limb, 33 mm. Probably in, or near, the Argonaut zone, middle of Horsetown Group. Locality of discovery not known. Holotype from the Academy of Natural Sciences, Philadelphia. p. 216.

(2, 3) *Hamiticeras philadelphium* nov. Holotype, right side and oblique ventral view. Total length, 61 mm.; width across both limbs, 45 mm. Probably near Argonaut zone, Cottonwood district, Shasta County. Holotype from Academy of Natural Sciences. p. 216.

(4, 5) *Helicancylus gabbi* nov. Two views of holotype. Greatest diameter of whorl, 55 mm. Cottonwood district, Shasta County. Locality and horizon not more definitely known. Holotype from Academy of Natural Sciences. Courtesy of H. A. Pilsbry. p. 222.

(6) Suture line of *Hamiticeras aequicostatum* (Gabb). (Pl. 37.) p. 216.





CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 80.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1, 1a) *Acroteuthis mitchelli* nov. Holotype with reflected end. Length of guard (incomplete), 114 mm.; maximum diameter, 21 mm. Mitchell zone, lower part of Horsetown Group; Loc. 1657 (C. A. S.), near Mitchell Creek, 7 miles south of Ono, Shasta County. p. 228.

(2) *Acroteuthis aboriginalis* nov. Holotype. Length of guard, 175 mm.; greatest diameter, 30 mm. Barr zone, middle part of Horsetown Group; Loc. 1347 (C. A. S.), 6 miles south of Ono, Shasta County. p. 225.

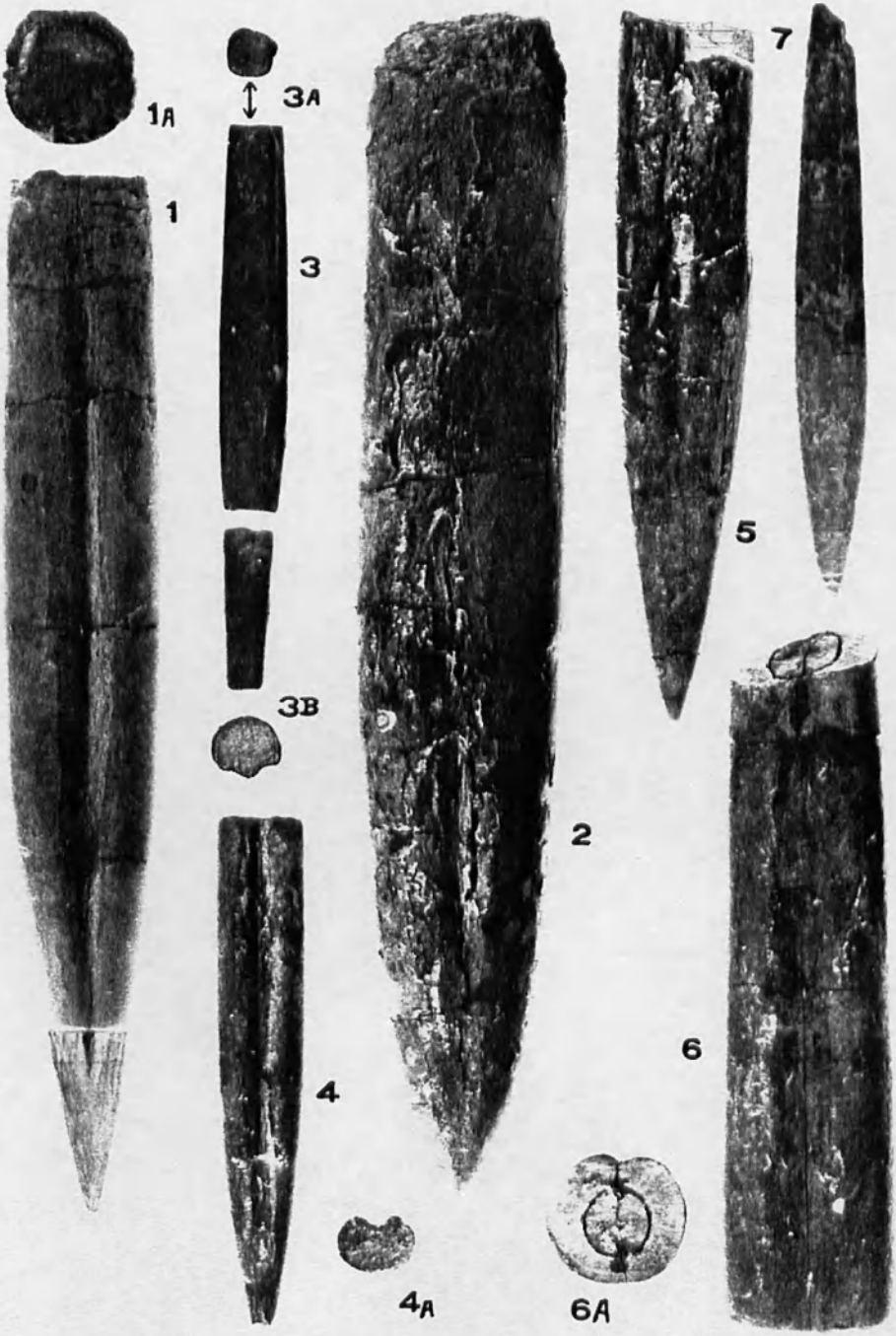
(3, 3a, 3b) *Hibolites diventroides* nov. (3) Holotype. Length, 52 mm.; greatest diameter, 9 mm.; length of lower section, probably part of the same individual, 22 mm. Found 600 feet below Mitchell zone, Fiddler Creek, Shasta County. (3a, 3b) Sections of holotype. p. 231.

(4, 4a) *Aulacoteuthis wyntoonium* nov. Holotype, with reflected end view. Length (incomplete), 68 mm.; greatest width, 12 mm. A little above the Mitchell zone, middle part of Horsetown Group; Fiddler Creek, Shasta County. p. 229.

(5) *Acroteuthis kernensis* nov. Holotype. Length of guard (incomplete), 98 mm.; greatest diameter, 20 mm. Paskenta Group, Devils Den district, Kern County. p. 226.

(6, 6a) *Acroteuthis divergens* nov. Holotype, with reflected end view. Length of holotype (incomplete), 98 mm.; greatest width, 23 mm. Lower part of Mitchell zone, Fiddler Creek, Shasta County. p. 229.

(7) *Hibolites cigarroides* nov. Holotype. Length (incomplete), 81 mm.; width near middle, 10 mm. Lower part of Horsetown Group, McCarthy Creek, Tehama County. p. 230.



CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 81.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1, 1a, 2) *Acroteuthis wilcoxi* nov. (1, 1a) Holotype, with reflected end view. (2) Longi-section of another example, showing the lower part of the alveolar pit, and the excentric position of the same, and of the axis. p. 227.

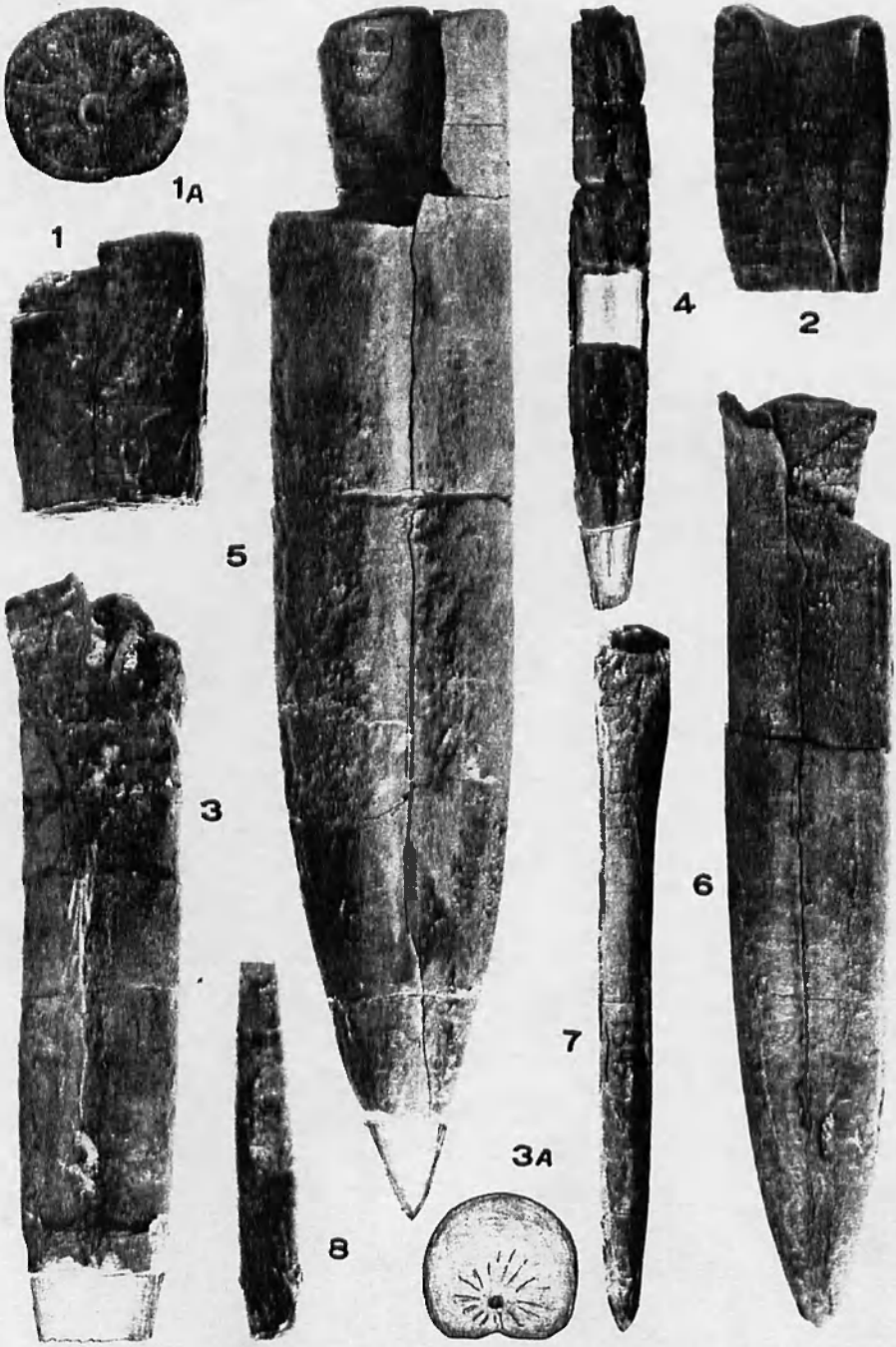
(3, 3a) *Acroteuthis onoensis* nov. (3) Holotype. Length (incomplete), 125 mm.; diameter, 20.3 mm. (3a) Section of the holotype, at point of break. Probably from the Barr zone, lower part of the Horsetown Group; Loc. 1657 (C. A. S.), Mitchell Creek, Shasta County. p. 227.

(4) *Aulacoteuthis wyntoonium* nov. Plesiotype, found at bucal end of a specimen of *Lytoceras aulacum* with other fragments of the same species. Near bridge at Ono, Shasta County. p. 229.

(5) *Acroteuthis shastensis* nov. Holotype. Length (incomplete), 152 mm.; greatest diameter, 31.7 mm. Upper part of Paskenta Group, in the Hamlin-Broad zone; Loc. 113 (C. A. S.), 4 miles southwest of Ono, Shasta County. p. 226.

(6) *Acroteuthis impressa* (Gabb). Plesiotype. Length, 123 mm.; greatest width, 22 mm. Mitchell zone, lower part of Horsetown Group; Loc. 1347 (C. A. S.), near Mitchell Creek, Shasta County. p. 225.

(7, 8) *Neohibolites fontinalis* nov. (7) Holotype. Length, 93 mm.; thickness, 7 mm. (8) Lower half of plesiotype, showing spindle-like form. Uppermost beds of Horsetown Group; Loc. 1345 (C. A. S.), Texas Springs, Shasta County. p. 231.



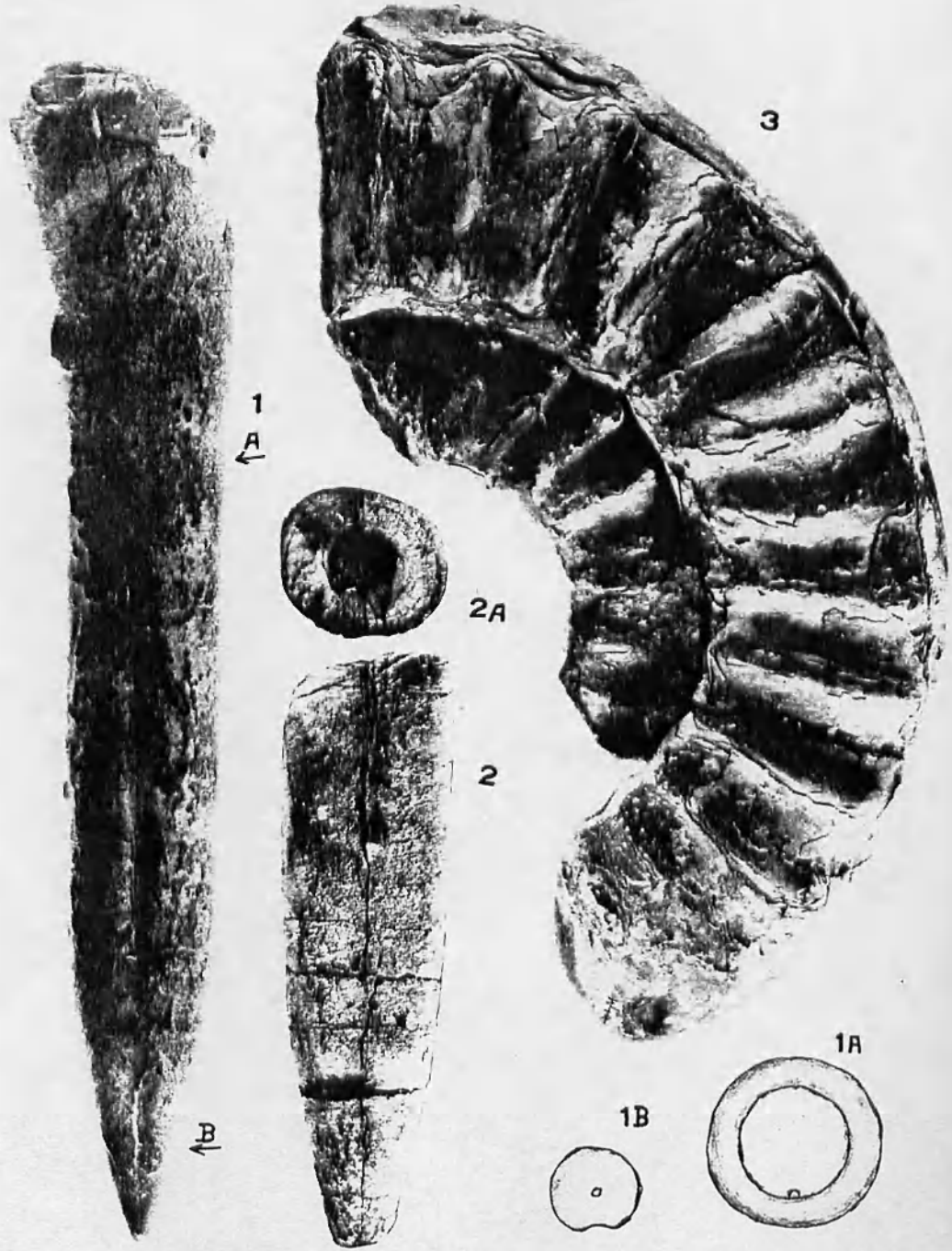
CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 82.—CRETACEOUS FOSSILS FROM CALIFORNIA

(1, 1a, 1b) *Acroteuthis impressa* (Gabb). (1) Holotype. Total length, 172 mm.; normal diameter, 27 mm. Museum of Paleontology, University of California collection. Probably lower Horsetown Group; Cottonwood Creek, Shasta County. (1a, 1b) Sections of holotype at A and B. p. 225.

(2, 2a) *Acroteuthis barrana* nov. Holotype, with reflected end view. Barr zone, lower part of Horsetown Group; Loc. 1347 (C. A. S.), near Mitchell Creek, Shasta County. p. 223.

(3) *Pervinquieria hulsana* nov. Holotype. Greatest diameter (est.), 325 mm.; thickness of whorl, 60 mm. Probably above the Neptune zone, upper part of Horsetown Group; found on Cottonwood Creek, Shasta County. Oregon State College collection. p. 198.



CRETACEOUS FOSSILS FROM CALIFORNIA

PLATE 83.—CRETACEOUS FOSSILS FROM CALIFORNIA

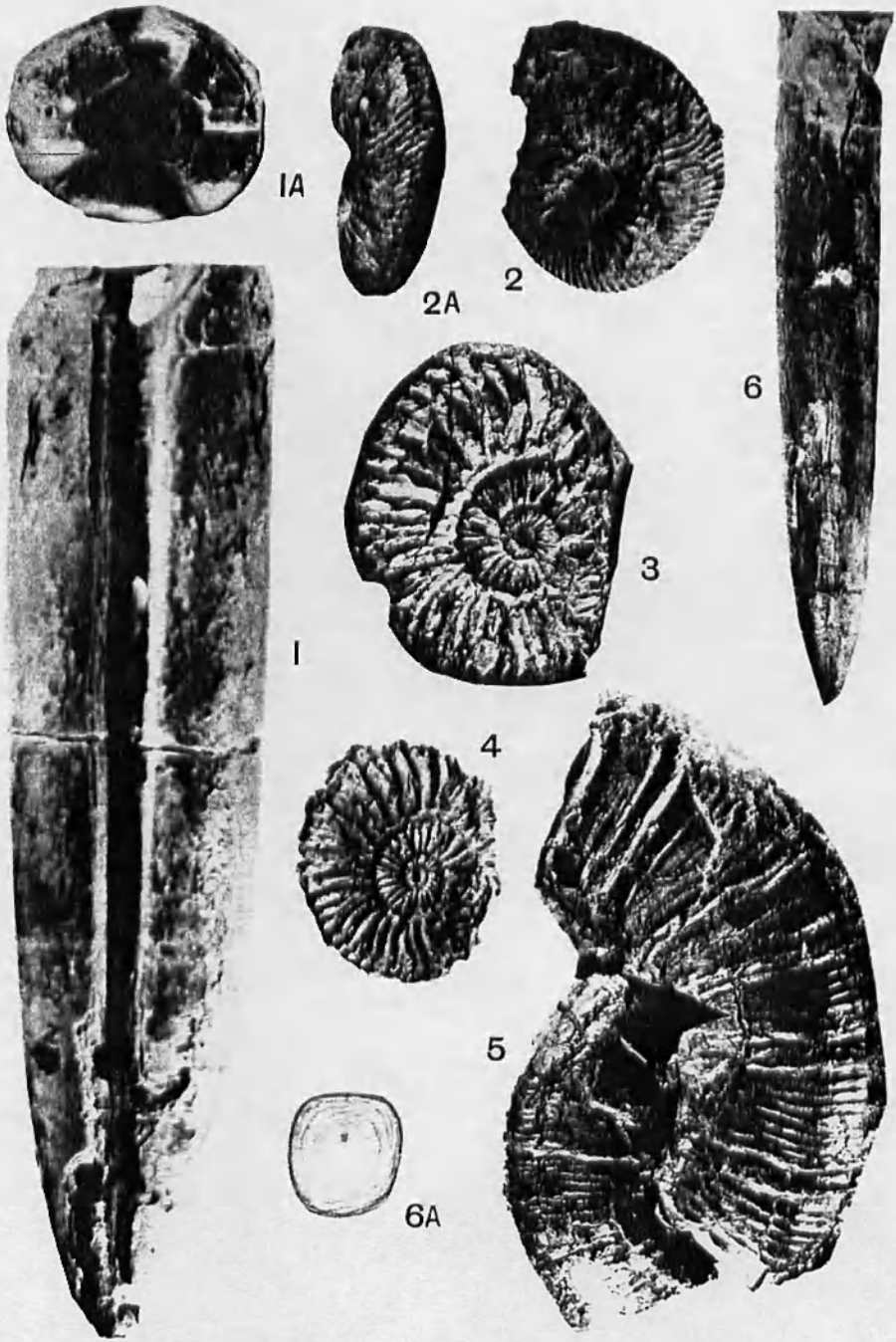
(1, 1a) *Acrotcuthis winslowensis* nov. Holotype. Length (incomplete), 147 mm.; dorso-ventral diameter, 30 mm.; lateral diameter, 35 mm. Found 2.5 miles north of Winslow bridge on Elk Creek, Glenn County. Basal beds of Paskenta group. (1a) Top view by reflection. p. 230.

(2, 2a) *Neocomites neocomiensis* (d'Orbigny). (2) Example found in Waltham Creek Valley, southwest of Coalinga, Fresno County, in basal conglomerates of Paskenta group. Greatest diameter, 20 mm.; thickness of whorl, 6 mm. (2a) Oblique peripheral view of same example. p. 166.

(3, 4) *Berriasella* cf. *crassiplicata* (Stanton). (3) Example found in near basal bed of Paskenta group on McCarthy Creek. Enlarged. (4) Plaster cast made from rock mold of same example. Natural size. p. 163.

(5) *Holcodiscus tehamaensis* nov. Holotype. Much reduced. Greatest diameter (est.), 250 mm.; height of whorl, 75 mm.; thickness of whorl, 60 mm. Lower part of Horsetown group; McCarthy Creek, Tehama County. p. 191.

(6, 6a) *Acrotcuthis macarthyensis* nov. Holotype. (6) Ventral view; reduced. (6a) Cross section of same. Basal beds of Paskenta group; McCarthy Creek, Tehama County. p. 230.



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